SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1898.

GENERAL PHYSICS.

1307. *Surface-Tension and Electrostatic Induction.* **S. J. Barnett.** (Phys. Rev. 6. pp. 257–284, 1898.)—To determine the surface-tension, the method of ripples is employed. Above the liquid is placed a conducting-plate, an air-condenser being thus formed. Electrification diminishes the apparent surface-tension, the diminution being *independent* of the sign. The relative diminution is greater with water than with mercury. A. Gs.

1308. *Viscosity of Insulating Liquids.* **W. Schaufelberger.** (Annal. Phys. Chem. 65. 3. pp. 635–640, 1898.)—This is a criticism of Quincke's work on viscosity of liquids in a constant electric field. König failed to observe any increase of viscosity in capillary tubes subjected to an electric field. The author explains the increased damping of Quincke's weights suspended in a liquid, by the consumption of energy in the variation of the charges of the weights, the liquid, and the walls of the vessel. E. E. F.

1309. *Tensile Strength.* **W. Voigt** and **L. Januszkiewicz.** (Göttingen Nachrichten, 1. pp. 107–112, 1898.)—In this paper the authors show that the tensile strength of a substance depends on the *difference* between the longitudinal and transverse tensile stress. This is proved by some experiments on a mixture consisting of 61·5 p. c. of stearic acid, 22·0 p. c. of palmitic acid, and 16·5 p. c. of German paraffin (melting-point 74°–80°). Rods of the mixture are broken under tension in the air, the pressure at right angles to the pull due to the atmosphere being 10 grammes per sq. mm.; the applied tensile stress per square mm. equals

$145 \pm 1 \cdot 9$. Rods are also broken in a vessel containing air at a pressure of 413 grammes per sq. mm.; the applied tensile stress per unit area equals $146 \pm 2 \cdot 5$. The applied stresses are thus practically the same in each case.

The results may be expressed in another form. Let P equal the longitudinal, and D the transverse pressure, in grammes per sq. mm. Then

In air .... $P = -135$, $D = +10$.
In the vessel ...... $P = +267$, $D = +413$.

It will be observed that the mixture breaks with a *tensile* fracture when subjected to a longitudinal *pressure*.

Besides the above there is a reference to some experiments of a kindred nature on rock-salt. A. Gs.

1310. *Pendulum Make and Break.* **C. T. Knipp.** (Amer. Journ. Sci. 5. pp. 283–284, 1898.)—A T-shaped frame of thin sheet-brass is pivoted at its centre to the pendulum-rod; in the lower end of the stem is a slot which engages a stud on the pendulum. The arms of the T end in platinum tips. Underneath these are flat steel springs, easily adjusted by means of set screws and resting on binding-posts. The circuit is closed when the pendulum passes through its lowest point. The circuit comprises a sounder. H. B.

1311. *Tidal Wave in Rivers.* **Partiot.** (Comptes Rendus, 126. pp. 1613–1615, 1898.)—The author explains a method of plotting tidal graphs for different stations on a river by means of observations taken at one of the stations, A suppose. It is necessary to assume some law of velocity of propagation for elementary waves supposed to start from A. The author tried five different formulæ, and compared the results with actual observations made on the Gironde and the Garonne. Boussinesq's formula,

$$\omega = \sqrt{gH}(1+3k'/4H),$$

appeared to be the best of the five. G. B. M.

1312. *Vaporisation of Thin Wires.* **M. Toepler.** (Annal. Phys. Chem. 65. 4. pp. 873–876, 1898.)—When a thin wire is vaporised by a strong electric discharge its vapour arranges itself in strata, as may be shown under favourable circumstances by depositing the vapour upon glass. A battery of condensers is fed by a 60-plate Toepler machine. It has two discharge-circuits in parallel, each provided with a spark-gap. The circuit containing the smaller spark-gap also contains the wire to be vaporised. The gaps are so adjusted that when the condensers are disconnected the discharge only passes through the circuit containing the thin wire. Then, on inserting the condenser, the discharge passes through both gaps on account of the sudden increase of resistance in the one containing the disintegrated wire. In this manner a single oscillation only passes through the thin wire, and a clear stratification is obtained. A glass plate is placed a few millim. below the wire, and after the discharge has passed a clearly stratified deposit, with a distance of one or two millim. between the strata, is obtained on the glass. When two glass plates are used, one above and the other below the wire, two stratified deposits, with exactly similar intervals, are obtained. The best results were obtained with a silver wire 10 cm. long and 0·012 cm. thick, a sparking-distance of 1·5 cm., an initial difference of potential of about 35,000 volts, and a capacity of about 0·25 microfarads in the condensers. The deposits obtained show that the vapour was stratified in lenticular masses, resembling the stratification in a vacuum-tube. Microscopically, the deposit resembles a fine sublimate. E. E. F.

1313. *Stability of Equilibrium*. **L. Lécornu.** (Comptes Rendus, 126. pp. 1777–1778, 1898.)—Let a material particle be acted upon by a force, not derivable from a potential, whose components parallel to rectangular arcs are linear homogeneous functions of x, y, z. Then the necessary and sufficient conditions for stable equilibrium at O are that there are three real lines through O at any point of which the force is directed towards O. These three lines are not orthogonal.

The introduction of a geometrical constraint may destroy stability. G. B. M.

LIGHT.

1314. *Refraction and Temperature.* **J. O. Reed.** (Annal. Phys. Chem. 65. 4. pp. 707–744, 1898.)—The refractive indices examined are those of fluorspar, quartz, calcspar, and a large number of glasses. The prisms are provided with an additional surface, giving a reflected image of the slit side by side with the spectrum. Any change of refractivity is then indicated by a relative shifting of the slit and the spectrum-lines. The dispersion is increased by heat in every case, even when the refractivity decreases. The latter happens in fluorspar, quartz, and in glasses after the softening temperature is reached. Before that temperature there is an increase of refractivity with temperature. In calcspar the refraction of the ordinary ray is only slightly affected by heat, but that of the extraordinary ray is considerably increased. Quartz shows a strong decrease of the refractive index, which becomes more accentuated at the higher temperatures. E. E. F.

1315. *Dispersion of Sylvine, and Metallic Reflection.* **A. Trowbridge.** (Annal. Phys. Chem. 65. 3. pp. 595–620, 1898.)—The author investigates the reflective powers of gold, copper, brass, iron, nickel, and speculum metal as compared with that of silver between $\lambda=1\,\mu$ and $\lambda=15\,\mu$. For the shorter wave-lengths he uses a fluorspar prism; for the longer ones two sylvine prisms in succession, since sylvine does not absorb the longer waves to the same extent as fluorspar. The refractive index of sylvine, as determined with the radiometer, varies from 1·480 for $\lambda=0{\cdot}982\,\mu$ to 1·452 for $\lambda=11{\cdot}197\,\mu$. The reflective powers of the metals mentioned are tabulated in detail. The magnetic metals show minima at about $\lambda=9\,\mu$, probably owing to a peculiarity of the magnetic susceptibility at those points. E. E. F.

1316. *Microscopic Images and Vision.* **L. Wright.** (Phil. Mag. 45. pp. 480–503, 1898.)—The author raises objections to Dr. Stoney's presentation of the theory of microscopic vision (Phil. Mag. 1896), and proceeds to consider how far the Abbé theory furnishes an adequate explanation of the facts. He is of opinion that "the trustworthiness of a microscopic image is in proportion as the object approximates to a self-luminous condition, and diminishes in proportion as it is, or has to be, examined by plane-wave illumination." T. P.

1317. *Theories of Microscopic Vision.* **G. J. Stoney.** (Phil. Mag. 46. pp. 156–162, 1898.)—L. Wright has published a criticism [see Abstract No. 1316] chiefly directed against a resolution of light into uniform plane wavelets which had been employed by the author in investigating the phenomena of microscopic vision. The present paper points out that Mr. Wright had formed an erroneous conception of this method of resolution, and endeavours to give such a description of it as can be understood by readers who are not experts in mathematical physics. This description may be summarised as follows :—

What the author had proved is that the system of waves propagated from a luminous punctum (or physical point) through a uniform transparent medium, may be resolved into the coexistence of innumerable uniform plane wavelets—wavelet meaning a wave of infinitesimal intensity. The luminous punctum may be either a self-luminous source of light, or one which becomes a source of light only when incident light falls on it; and the medium may be either isotropic (in which case the waves to be resolved are spherical) or double-refracting (in which case they have the form of the wave-surface in crystalline media).

Light really consists of electromagnetic waves; but that useful branch of Optics called Geometrical Optics is built upon an hypothesis, in which a more easily manipulated machinery is substituted for the waves. In Geometrical Optics the light is treated as if it consisted of "rays of light" subject to the laws of reflection, refraction, etc., and which, where they converge, produce an illumination equal to the sum of their separate illuminations. This hypothesis is legitimate, because it yields by an easy process valuable results; since it can be proved that the images which it furnishes are correctly situated and are in other respects a useful approximation to the images produced by the waves which are what really exist in nature.

Now the new resolution into plane wavelets may be perhaps most easily conceived by first picturing the "rays" of Geometrical Optics diverging from the punctum, and by then substituting for *each* of these rays a train of plane wavelets advancing in the direction of the ray, and with their fronts perpendicular to the ray if the medium be isotropic or oblique to it in double-refracting media. The plane wavelets are, in fact, in all cases tangential to the wave-surface in the medium; and the rays of Geometrical Optics are in reality not rays "of light," but mere geometrical lines from the source of light to the points of contact between the plane wavelets and the wave-surface. AUTHOR.

1318. *Study of "Flicker."* **T. C. Porter.** (Roy. Soc. Proc. 63. pp. 347–356, 1898.)—In the first part of the paper the author describes experiments made to ascertain the exact relative rotations at which the flicker of a disc, half black, half coloured, vanishes in the different colours of the spectra of sun- and lime-light formed by a diffraction-grating of 14,434 lines to the inch. The results may be summed up as follows :—The rate of rotation of the disc that the flicker may just vanish is highest for the yellow, decreasing for the succession of colours on either side of this one, being the same for the deepest visible crimson and full green. When the intensity of the different spectra is varied, the greater the intensity the more rapid is the rate of rotation necessary for flicker just to vanish. Research was made to discover in what way the rotation of a black and coloured disc must be varied for flicker to vanish, when the proportion of the coloured to the black sector varied by stages of 10° at a time, the experiments being carried out in each of the main colours of the limelight spectrum. The results are expressed in a series of remarkable curves.

The remainder of the paper is devoted to the discussion of these curves; and it concludes by proving, from a series of points taken at random on one of them, that the duration of the impression on the retina undiminished is within narrow limits inversely proportional to the time during which the retina is stimulated. Some other conclusions of interest are arrived at; *e.g.*, (1) When flicker has just vanished, the effective stimulus at any point of the retina is to the maximum stimulus the coloured sector can produce, as the angle of the yellow sector is to the angle of the whole disc (*i.e.* 360°), the illumination being supposed constant. (2) The coloured sector always requires a finite time in order to produce its maximum effect on the retina. (3) When the width of the white or coloured sector is increased in steps of 10° at a time, the increment in the apparent brightness in the rotating and flickerless disc follows, within the errors of experiment, the series of 1/0, 1/1, 1/2, 1/3, 1/4, etc.

AUTHOR.

1319. *Adjustable Röntgen-Ray Tubes.* **A. A. C. Swinton.** (Archives of the Röntgen Ray, 2. 3. pp. 40–46, 1898.)—The several methods of making X-ray tubes adjustable, described in Abstract No. 1218, are discussed from the point of view of practical radiography. That in which the anode is fixed, and the kathode is movable in and out of a glass annex, is preferred, as with it the point of origin of the rays is constant, while a travel of ½ inch is sufficient to alter the penetration from the highest to the lowest value, so that definition is not interfered with. Kathodes should be well polished and accurately curved. They should not be too small or they become overheated, nor very large, as in that case only the central portion is active. The platinum anti-kathode is best mounted on a massive block of aluminium, to absorb the heat and prevent deformation and blackening. Blackening increases the resistance, not only by occluding the residual gas but also by forming a non-fluorescent coating on the glass. The quantity of X-rays and their penetrative value are distinct. The latter depends largely upon the potential difference, but is independent of the material used for the anti-kathode. The quantity is, however, greatest with anti-kathodes of the highest atomic weight.

AUTHOR.

1320. *Pin-hole Röntgen-Ray Camera.* **A. A. C. Swinton.** (Archives of the Röntgen Ray, 3. 1. pp. 15–16, 1898.)—A pin-hole camera is employed to compare the active anti-kathode areas in various forms of focus-tubes, with a view of ascertaining the design best fitted to give the sharpest possible definition in radiographs. Endeavours to detect reflected Röntgen rays gave negative results. AUTHOR.

1321. *Source of Röntgen Rays in Focus Tubes.* **A. A. C. Swinton.** (Roy. Soc. Proc. 63. pp. 432–437, 1898; also Nature, p. 286, 1898.)—The source is investigated with a pin-hole camera, fitted with a fluorescent focussing-screen. The dimensions and form of the source vary considerably when the distance between kathode and anti-kathode is altered. Those kathode rays which impinge most normally on the anti-kathode are most effective in producing Röntgen rays. The kathode stream usually proceeds almost entirely from a small central portion of the kathode surface. The kathode rays cross at the focus, and the divergent cone retains any special characteristics of the convergent cone. The main source of the Röntgen rays is on the anti-kathode, but an appreciable quantity also proceed from all those portions of the glass that show green fluorescence. This fluorescence is due to S. P. Thompson's para-kathodic rays, which start not from the kathode but from the anti-kathode. The Röntgen rays that come from the glass are generated by the impact of these para-kathodic rays; and the latter are most plentiful along the path in which the kathode rays would be reflected from the anti-kathode, according to the law of equal angles. AUTHOR.

1322. *Discharging Action of Uranite.* **E. Villari.** (N. Cimento, 7. pp. 46–50, 1898.)—The author shows that the radiation from uranium and its compounds, discovered by Becquerel, behaves in several respects like X-rays. The radiation from uranite imparts to air or coal-gas the power of discharging an electrified conductor, and this property persists for some time after the action of the radiation has ceased, becoming gradually more feeble. Air exposed to uranium radiation and then blown past the extremity of an electrified wire loses its power of discharging electricity of the same sign as that on the wire, but will still discharge electricity of the opposite sign. If the wire is held close to the end of the tube from which the gas emerges, the latter loses its power of discharging either kind of electricity. When wrapped in paper the uranite is no longer able to affect the air outside the paper; either actual contact is necessary or, more probably, the active radiation is absorbed by the paper. A photographic plate, shut up in its dark slide, is not affected by the action of the mineral in 3 hours; but an effect is produced by uraninite or uranium nitrate separated from the plate by two thicknesses of black paper. J. L. H.

1323. *Phosphorescence of Rarefied Gases.* **H. F. Newall.** (Cambridge Phil. Soc. Proc. 9. 6. pp. 295–302, 1897.)—Previous experiments on electric discharges in rarefied gases by Morrem, Sarasin, and J. J. Thomson, indicate that phosphorescence after cessation of the discharge only occurs in mixtures of gases, or simple gases which polymerise. The author's attention was drawn to the subject by observing brilliant phosphorescence in mixtures of oxygen with other gases when rendered luminous by electrodeless discharges. He finds that in all cases the spectrum of the phosphorescent glow is a continuous one, even when the pressure of the gas is only 0·1 mm. mercury; in no case have lines or bands been observed. On concentrating a beam of sunlight upon the phosphorescent gas no scattering of polarised light is observed, so that there is no evidence of the presence of solid particles in the gas. Black or brown deposits appear occasionally on the inside of the (electrodeless) glass tube; sometimes they form a thick film, and they indicate that chemical changes are produced by the discharge. The author connects white phosphorescence with mixtures of oxygen and carbon, yellow with oxygen and nitrogen, and blue with oxygen and sulphur. The afterglow appears at pressures between 0·01 and 0·6 mm., and is greatest at about 0·4 mm., the limits varying slightly for different gases. By altering the pressure during phosphorescence increased brightness may be produced.

When a mixture of gases is first compressed the operation renders it luminous; but if it be then rarefied and re-compressed it does not again glow, unless it be put in communication, while rarefied, with a bulb in which an electrodeless discharge is taking place. The author considers that the gaseous molecules form themselves into groups at low pressures, which are destroyed as the pressure is increased, and he describes phenomena supporting this view. The spectrum of the pressure-glow differs from that following electrical discharge, the pressure-glow containing four bright oxygen bands. The luminosity of condensing nebulæ may be due to pressure-glow; in the centre of the nebula the pressure is too great, and on the edge too small, for visible phosphorescence. The luminosity of the intermediate layer will be persistent on account of the streaming-in of rarefied gas, and will not point to a high temperature of the nebula. J. L. H.

HEAT.

1324. *Boiling-point Curve for Benzene and Alcohol.* **E. F. Thayer.** (Journ. Phys. Chem. 2. pp. 382–384, 1898.)—The minimum boiling-point for benzene-alcohol mixtures is 66°·7 C., the pressure being 73·7 cm. of mercury; the critical mixture contains 66·5 per cent. of benzene. R. E. B.

1325. *Specific Heat of Metals at Low Temperatures.* **C. C. Trowbridge.** (Science, 8. pp. 6–11, 1898.)—For Cu, Fe, Al, which gave ·0940, ·1162, ·2173 for the mean specific heats between 23° and 100° C., were found ·0868, ·0914, ·1833 for the mean specific heats between the boiling-point of oxygen (−181°·4 C.) and normal temperatures (11° to 15° C.). R. E. B.

1326. *Emissivity of Platinum.* **J. E. Petavel.** (Roy. Soc. Proc. 63. pp. 403–405, 1898.)—The emissivity of a bright Pt wire, ·112 cm. in diameter, which served both as radiator and thermometer, was measured in air, CO_2, H, O, and steam, at pressures from 1 to 228 cm. of mercury and at temperatures between 200° and 1779° C. The radiation of Pt between 500° and 1779° was also studied bolometrically, and Weber's radiation-formula was confirmed for temperatures between 400° and 800°, while the formulæ of Dulong and Petit, Stefan and Rosetti failed to express the experimental results obtained. The intrinsic brilliancy of Pt in candles' power per sq. cm. was found to be expressible in terms of degrees C by $\{(t-400)/889{\cdot}6\}^{6{\cdot}9}$. R. E. B.

1327. *Use of Standard Thermometers.* **A. W. Warrington.** (Chem. News, 78. pp. 6–7, 1898.)—An ordinary Jena thermometer, provided with a Reichsanstalt certificate, was compared with a Tonnelot standard from the Bureau International. By reading the Jena thermometer upright, stem immersed, correcting for zero point and for the errors detailed in the certificate, results were obtained in practical agreement with the Paris hydrogen scale, the mean error being only ± 0°·004. R. A. L.

1328. *Absolute Temperature.* **K. Schreber.** (Annal. Phys. Chem. 65. 3. pp. 648–654, 1898.)—The author points out the advantages of the "geometrical" scale of temperatures, based upon the percentage change of a certain property (volume, tension, etc.), in comparison with the generally adopted arithmetical scale. The laws and equations of thermodynamics admit of a simpler expression by means of the geometrical scale, which was originally proposed by Dalton. It is the only scale which is absolutely independent of the properties of any given substance, and of speculations with regard to the absolute zero of temperature.

E. E. F.

1329. *Kinetic Theory of Gases.* **H. Staigmüller.** (Annal. Phys. Chem. 65. 3. pp. 655–669, 1898.)—This is an attempt to substitute definite conceptions of motion for the kinetic theory, which is solely based upon the two laws of thermodynamics. The motion of a gaseous molecule consisting of n atoms is completely defined by $3n$ independent variables. Three of these serve to fix the motion of translation of a single atom, and three more its rotation, with reference to two other atoms. Of the remaining $(3n-6)$ coordinates three give the mutual distances of the three atoms, and then the remaining coordinates of any further atoms may be determined with reference to the first three. If e is the mean value of the kinetic energy corresponding to the $3n$ coordinates, the total energy of the system is $6(n-1)e$. The author terms $6(n-1)$ the "heat dimension" of the gas, and denotes it by θ. The constant is characteristic of the thermal properties of a gas. It has the value 5 in the gases CO, NO, and the haloid acids, 7 in such bodies as water, CO_2, and SH_2, 18 in PCl_3 and $CHCl_3$, and 22 in the chlorides of silicon, tin, and titanium. The specific heat at constant pressure is calculated from the heat dimension by the formula

$$C_p = 0{\cdot}98835\frac{\theta+2}{\mu},$$

where μ is the molecular weight. This formula accords well with experiment. E. E. F.

1330. *Law of Dulong and Petit.* **H. Staigmüller.** (Annal. Phys. Chem. 65. 3. pp. 670–672, 1898.)—The author attributes temperature to the mean kinetic energy of the atom vibrating about a mean position. He deduces from general principles the equation

$$\frac{1}{2}\frac{C'_v}{nN} = \frac{3}{\theta}\frac{C_v}{N},$$

where θ is the "heat dimension," n the number of atoms in the molecule, N the number of molecules in 1 gramme, C_v the gaseous and C'_v the solid specific heat. Putting $C_v = 0{\cdot}98835\ \theta/\mu$ he obtains

$$aC'_v = 5{\cdot}93,$$

a close approximation to Dulong and Petit's law. E. E. F.

1331. *Absolute Measurement of Radiation.* **F. Kurlbaum.** (Annal. Phys. Chem. 65. 4. pp. 746–760, 1898.)—The author reduces the heat absorbed by the bolometer to a Joulean current heat, and thus makes it amenable to absolute measurement. The bolometer is put into one gap of a Wheatstone bridge, the other three gaps being thick wires, whose resistances are not altered by the current. The bolometer is subject to radiation and its resistance noted. The same resistance is then produced by current heating, and a comparison of the resistances with and without radiation gives an absolute measure of the latter. The method is then used to determine the radiation of an "absolutely black" body. The radiation from such a body at 100° to another at 0° is found to be

$$0{\cdot}01763\frac{\text{gr.-cal.}}{\text{cm.}^2\ \text{sec.}}$$

The author claims to be able to measure the radiation from any source in absolute measure with ease and accuracy. E. E. F.

SOUND.

1332. *Lecture-experiments on Sound.* **G. Bongiovanni.** (Rivista Scientifica, 30. pp. 123–131, 1898.)—The author describes the use of a spirally coiled wire to demonstrate the various equations for the velocity of sound, particularly

$$v = \sqrt{g/a},$$

where a is the elongation produced in the stretched spring, or

$$v = L\sqrt{g/b},$$

where L is its length and b is actual extension. A. D.

1333. *Motion of Vibrating Strings.* **G. Klinkert.** (Annal. Phys. Chem. 65. 4. pp. 849–872, 1898.)—The motion of a string kept vibrating by means of an electromagnetic device is investigated by a stroboscopic method and by photography, after the method devised by Krigar-Menzel and Raps. In one arrangement the string acts as its own interrupter. The mode of vibration of the string, and the number and intensity of the overtones depend upon the position of the electromagnet, the place of the mercury contact, the depth of immersion of the platinum point, and the tension of the string. To produce any required overtone, the electromagnet should be placed immediately over the first ventral segment, where the amplitude of the vibration is greatest in comparison with that of the fundamental. The third harmonic is difficult to eliminate, except by employing an auxiliary string to act as interrupter for the string under examination. E. E. F.

1334. *Tuning-forks.* **C. Stumpf** and **M. Meyer.** (Annal. Phys. Chem. 65. 3. pp. 641–644, 1898.)—This is a renewed criticism of Appunn's standard tuning-forks and whistles. The authors point out that calculation from geometrical dimensions cannot be relied upon to govern even the correct octave of the very high notes. E. E. F.

1335. *Tuning-forks.* **F. Melde.** (Annal. Phys. Chem. 65. 3. pp. 645–647, 1898.)—This paper confirms the criticism of the previous one, and shows that the values attached to Appunn's standards are far too high. E. E. F.

1336. *Voice from Phonographs.* **Marage.** (Comptes Rendus, 126. p. 1202, 1898.)—New harmonics alter the vowels: these come mainly from the mouth-tube, partly from the vibrating disc. Altering the speed of rotation affects the pitch of the vowel-note, and modifies or transforms the vowel completely. The greater or less conicity of the resonator affects the loudness very little: the resonator must not import new vibrations of its own. The loudness increases, within limits, with the size of the vibrating disc: it seems to be also proportional to the pressure of the style on the vibrating disc and on the cylinder. A. D.

ELECTRICITY.

1337. *Electric and Magnetic Field produced by a Moving Charged Point.* **A. Liénard.** (Écl. Électr. 16. pp. 5–14, 53–59, & 106–112, 1898.)—The differential equations of the electromagnetic field can be put in the form

$$\left(V^2\Delta - \frac{d^2}{dt^2}\right)\psi = -4\pi V^2\rho,$$

where ψ corresponds to the potential $\iiint \frac{\rho}{r}\,dx\,dy\,dz$ in the theory of instantaneous action. Corresponding expressions hold for F, G, H, the components of vector-potential. The most general integral is

$$\psi = \int \frac{\rho\left[x'y'z'\left(t-\frac{r}{V}\right)\right]}{r}\,d\omega',$$

r being the distance from M where ψ at time t is required to $x'\,y'\,z'$, $d\omega'$ an element of volume at $x'\,y'\,z'$, and ρ the density at $x'\,y'\,z'$ at the time $t-\frac{r}{V}$. V is the velocity of light. M. Liénard shows that, the whole charge e being contained in a very small volume and moving with velocity u, we may write

$$\psi = \frac{e}{r\left[1-\frac{u}{V}\cos(ur)\right]},$$

from which and the corresponding expressions for F G H he finds the components of displacement $f\,g\,h$, and of magnetic force $\alpha\,\beta\,\gamma$, at M at time t. The results are applied to (i.) a closed circuit; (ii.) the loss of energy by radiation; (iii.) the force exerted on itself by a charged particle in motion. The consequences of u being assumed greater than V are discussed.

S. H. B

1338. *Electromagnetic Hypotheses.* **E. Wiechert.** (Göttingen Nachrichten, 1. pp. 87–106, 1898.)—These hypotheses are a modification and extension of Maxwell's electromagnetic theory, and the endeavour is made to include in their scope such recent work as kathode rays and Zeeman's phenomenon. E. H. B.

1339. *Atmospheric Discharges of Electricity.* **S. A. Montel.** (Écl. Électr. 16. pp. 183–188, 1898.)—An electrified cloud and the earth, or two oppositely electrified clouds may be considered as forming a condenser, the discharge of which is a flash of lightning.

If there be in the neighbourhood a closed circuit without electromotive force of its own, the flash induces in the circuit a transient current. In the author's notation, Q is the absolute quantity of electricity on either armature of the condenser; C the capacity of the condenser; L the coefficient of self-induction of the primary circuit, *i. e.* the course of the flash; L′ the coefficient of self-induction of the induced circuit; M the coefficient of mutual induction; R R′ the resistances; $i\ i'$ the intensities at time t. Applying the usual formulæ, the writer considers two cases, (1) that the discharge is continuous; (2) that it is oscillatory. Making

$$m=\sqrt{\frac{1}{CL}-\frac{R^2}{4L^2}},$$

$$f=\frac{Q}{mLC}, \qquad \beta=\frac{R}{2L},$$

we have

$$i=f\epsilon^{-\beta t}\sin mt,$$

from which the induced current i' is obtained. The results for the cases (1) and (2) are given in a table. In case of an oscillating discharge, if m/β be very great, $\int i'^2dt$ is independent of $\frac{R'}{L'}$. If m/β be not very great, $\int i'^2dt$ is generally greater as $\frac{R'}{L'}$ is smaller. He concludes that if we have two induced circuits, for one of which $\frac{R'}{L'}$ is very great, and for the other very small, it may be possible, by measuring the quantities $\int i'^2dt$ in the two cases separately, to determine, within limits, the nature of the atmospheric discharge. S. H. B.

1340. *Ultra-Violet Light and Conductivity of Vapours.* **J. Henry.** (Cambridge Phil. Soc. Proc. 9. 6. pp. 319–322, 1897.)—Experiments are described which show that the rate of leakage of electricity from a charged copper disc exposed to ultra-violet light is not increased, but rather diminished, by surrounding the disc with an atmosphere of iodine or amyl-nitrite vapour. The author concludes that these vapours are not rendered conductors by absorption of ultra-violet radiation. J. L. H.

1341. *Contact-Electricity of Metals.* **Kelvin.** (Phil. Mag. 46. pp. 82–120, 1898; a paper read at the Royal Institution, May 21st, 1897.)—The first part of this paper is historical. Volta's fundamental experiments and others are described and deductions drawn from them. The author's own researches upon the measurement of contact-force, and those of Pellat, Pfaff, Bottomley, and Erskine-Murray are referred to. The author then discusses thermo-electric E.M.F. If a closed circuit consisting of, say, copper and iron is broken at one of the junctions, and a quadrant electrometer inserted, the deflection will be a measure of the contact-force + the thermo-electric E.M.F. due to any difference of temperature between the junctions. If a copper plate is allowed to move inwards in the gap, moving on the copper part of the circuit (which is supposed to be of large cross-section), cold will be produced at the other junction; if it is drawn out heat will be evolved, but such heat is not the thermal equivalent of the work done: probably the greater part of the work done in drawing out the plate against the electric attraction goes to storing up electrostatic energy. Reasons are then given in support of the view that the Peltier evolution of heat is not the thermal equivalent of E.M.F. at a junction.

Volta's experiments render it certain that two metallically connected pieces of metal attract one another, the force of attraction being a resultant of chemical affinity between thin surface-layers of the two metals. The work done by electric attraction in allowing two such plates of copper and zinc to approach each other is calculated for various distances ranging from 1/100 cm. to $1/10^{10}$ cm. The value of the force, heat evolved, and rise in temperature are also given. It is inferred that the attraction does not vary inversely as the square of the distance for such small distances as $1/10^{9}$ cm., because the value of the force then becomes so large as to be inadmissible; at smaller distances the electric attraction merges into molecular force between the metals. Suppose a disc of zinc to be metallically connected with a disc of copper at some distance from it, then disconnected and brought near to the copper; no work is done in this movement by the electric attraction. If connection is now made, current flows and heat is generated. Imagine a pile of alternate discs made up in this way, and finally metallic connection made between all the discs. If the discs are thin, and the distances between them are suitably small, sufficient heat will be generated to give a column of brass. This would take place if we suppose the electric attraction to vary inversely as the distance for discs 10^{-8} cm. thick at a distance of 10^{-9} cm. apart, and the resulting heat would be much the same as the heat of formation of brass experimentally determined. The author concludes with an argument against Lodge's chemical theory of contact-force and with experiments on uranium rays. W. R. C.

1342. *Spark Discharge.* **R. Swyngedauw.** (Annal. Phys. Chem. 65. 3. pp. 543–552, 1898.)—This is a reply to G. Jaumann, who denies that if two different spark-gaps have the same potential with a static charge, they also have the same potential with a dynamic charge, provided the electrodes are polished and protected from radiation capable of provoking the discharge. The author points out that Jaumann's branch-circuit experiment disproves his own proposition. Further, according to Jaumann, the discharge-potential of an exciter which is charged by an influence-machine is much less than the discharge-potential measured according to the static method, in which the charges are in equilibrium at any given instant. The author points out that the oscillations supposed to accompany the charging process have never been proved to exist, and that the balance of evidence is in favour of the charge by an influence-machine being static. E. E. F.

1343. *Flame Gases and Electric Discharges.* **K. Wesendonck.** (Annal. Phys. Chem. 65. 3. pp. 553-566, 1898.)—To investigate the cause of the comparative immunity of factory chimneys from lightning discharges, the author reproduces the conditions as far as possible by mounting a horizontal copper tube on a stand, and attaching to one end of it a miniature lightning-conductor, the other end being bent down and serving as an inlet for the products of combustion of a Bunsen burner or other flame. Opposite the lightning-conductor is mounted a metallic disc charged by an influence-machine, and representing an electrified cloud. To prevent discharge from the "chimney," the near end is surrounded by a separate cylinder with a rounded edge. When the machine is working steadily, and the distances are properly chosen, there is a steady glow-discharge between the positive rod and the negative disc, and an electrometer connected with the disc has a constant deflection. On putting a flame under the chimney, the glow is replaced by a brush- or spark-discharge. It is remarkable how sensitive the glow is even to small quantities of products of combustion. When the air of the room contains a certain proportion of them, the glow does not reappear until the air is renewed. When the machine is worked slowly and a brush-discharge is just about to pass into a glow-discharge, flame-gases stop the discharge until the potential rises and a brush-discharge breaks forth again. Sparks are also called forth by products of combustion which have been kept for some time in a copper box, by air containing steam, by simple streams of gas. The author ascribes the immunity of chimneys and the effects observed to the presence of streams of gases of certain substances, or of special temperatures and velocities. E. E. F.

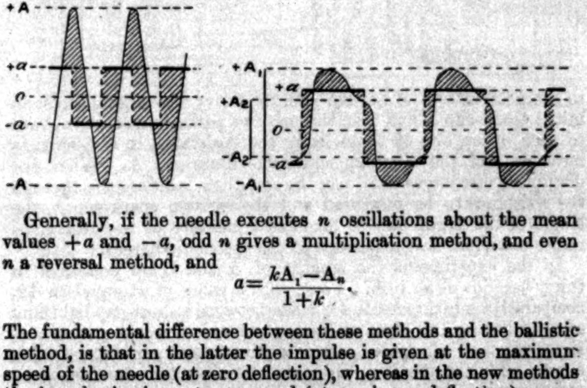
1344. *Galvanometry of Spark Discharges.* **A. Witting.** (Annal. Phys. Chem. 65. 3. pp. 621-628, 1898.)—If a multiple influence machine is worked at a constant speed by a motor, and the stream of sparks is sent through a Wiedemann galvanometer of long period, the constant deflection obtained may be measured by the ordinary methods. But if the machine is worked by hand, the deflection undergoes irregular oscillations about a mean value, and the pitch of the note produced by the sparks oscillates correspondingly. The mean current may be obtained by a large number of successive observations or by noting the mean pitch of the note and the corresponding deflection. But surer ways are offered by "multiplication" and by Toepler's reversals. These give better deflections, and are in themselves mean-value methods. They may be described as follows:—On sending the current of sparks through the coil of the galvanometer, the needle is deflected from its position of rest in the magnetic meridian and commences to oscillate about a new value, whose distance from zero may be denoted by $+a$. But the current is reversed at the first turning point of the needle, and the new position of equilibrium is therefore $-a$. If the reversal is repeated at every first turning point, a limiting state is eventually reached in which the needle attains alternately two elongations symmetrical to the zero, $+\mathrm{A}$ and $-\mathrm{A}$, and

$$(1) \quad \ldots\ldots\ldots \quad a=\frac{k-1}{k+1}\mathrm{A};$$

$$(2) \quad \ldots\ldots\ldots \quad k=\frac{\mathrm{A}+a}{\mathrm{A}-a}=\text{the damping ratio.}$$

This method may be called that of simple multiplication.

The method of simple reversal is obtained by reversing the current not at every first, but at every second turning point of the needle, so that in the final state the needle attains four successive elongations $+\mathrm{A}_1$, $+\mathrm{A}_2$, $-\mathrm{A}_1$, and $-\mathrm{A}_2$. The two cases are illustrated in the diagram.



Generally, if the needle executes n oscillations about the mean values $+a$ and $-a$, odd n gives a multiplication method, and even n a reversal method, and

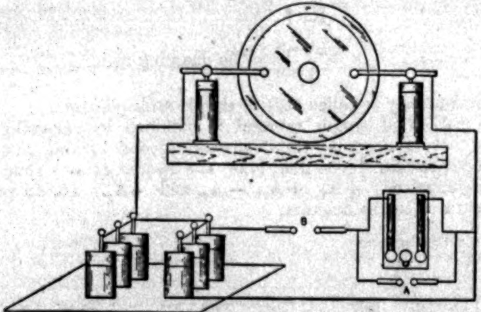
$$a=\frac{k\mathrm{A}_1-\mathrm{A}_n}{1+k}.$$

The fundamental difference between these methods and the ballistic method, is that in the latter the impulse is given at the maximum speed of the needle (at zero deflection), whereas in the new methods the impulse is given at zero speed (at maximum deflection).

The author made a number of experiments by the new methods, in order to determine the relation between the strength of the current and the various elements of the circuit. He found that the current-strength is practically independent of the resistance in the circuit and of the length of the spark-gap, except that with long spark-gaps a considerable loss by radiation took place unless U-tubes containing $CuSO_4$ solution were inserted. Further, the current-strength was found within wide limits to be proportional to the speed at which the machine was worked. E. E. F.

1345. *Disruptive Discharge, Leakage and Ohmic Resistance.* **A. J. Wurts.** (Elect. World, 32. pp. 91–92, 1898.)—This is an account of some experiments on the relative values of lightning arresters with and without resistances in series with the spark-gap. The method of experiment is as follows:—A static machine (see fig. 1) driven by an electric motor at constant speed is used to charge a battery of Leyden jars, the latter discharging across an initial spark-gap B and then through two paths connected in shunt to each other, one of these being the resistance it is desired to measure, and the other an adjustable spark-gap A. When the disruptive discharges pass over B, and then indifferently through the resistance to be measured and the variable spark-gap A, the length of the A gap may be taken as a measure of the resistance under test offers to the passage of disruptive discharges.

Fig. 1.



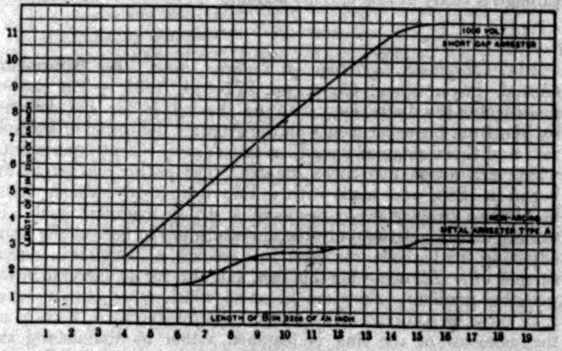
In the experiments the lengths of A and B are measured in thirty-seconds of an inch. First, with a value of B equal to 12, comparative measurements are made between a short-gap lightning arrester having 120 ohms resistance and two gaps aggregating one-sixteenth inch air-space, and a series of six gaps aggregating eleven sixty-fourths inch air-space, forming the standard non-arcing metal lightning arrester. With the former the gap A has a value 9 and with the latter only 2·75, showing that a non-inductive resistance in series with two spark-gaps offers over three times the resistance to disruptive discharge that six gaps offer without resistance in series.

On removing the spark-gap A and placing first one and then the other arrester in series with B, the following results are obtained:—

	Number of Discharges.	Duration in minutes.	Rate per minute.
Non-arcing metal......	50	5	10·0
„ „ „	40	5	8·0
Short gap	62	5	12·4
„ „	55	5	11·0

From this result it would appear that the ohmic resistance does not allow complete discharge of the Leyden jars; consequently it requires less time to re-charge the jars, and the discharges occur more frequently. Fig. 2 shows the relation between the spark-gaps A and B when both are varied and when the non-arcing metal and the short-gap arrester are respectively in shunt with A. The experiments throughout encourage the use of the non-arcing metal arrester. W. G. R

Fig. 2.



1346. *Kathode Jets.* **C. E. S. Phillips.** (Electrician, 41. pp. 425–426, 1898.)—This article describes an experiment to show that the green flecks, which appear upon the inner surface of a highly-exhausted and electrically-stimulated Crookes' vacuum-tube, have their origin in jets which emanate from the negative electrode. The special form of vacuum-tube employed by the author was so constructed that the kathode carried upon its inner extremity a small disc of aluminium, free to rotate, and movable when necessary through the action of an external magnet suitably arranged to affect an insulated iron projection from the edge of the disc itself. The tube having been highly exhausted, a discharge was passed through it until green flecks made their appearance upon the inner surface of the glass, and these moved correspondingly when the kathode disc was partially rotated. On stopping the discharge, a few of the luminous patches could still be seen clinging to the walls of the tube, sometimes shimmering for as long as 10 seconds. A movement of the disc again produced a corresponding movement of the patches, showing that the electrode continued to give off a radiation long after the discharge in the tube had ceased to pass. Any slight direct influence of the external magnet upon the movements of the green patches was carefully eliminated, and the conclusion arrived at that not only is the position of these patches determined by the position of the negative electrode, but also that the jet-like emissions to which they owe their origin continue to be given off for some seconds after the stimulation of the tube has ceased. The effect of modifying the electrostatic condition of the glass walls is also incidentally mentioned, while its bearing upon the formation of the jets leads to a suggestion that many of the phenomena observed in focus-tubes may be better understood through a study of this curious action. AUTHOR.

1347. *Magnetic Deflection of Kathode Rays.* **A. Schuster.** (Annal. Phys. Chem. 65. 4. pp. 877–884, 1898.)—The author investigates the discrepancy between the values for e/m deduced by him from his experiments on the magnetic deflection of kathode rays and those obtained from Kaufmann's more recent experiments, which are about five times greater. The author's experiments, begun in 1888, were made with a thin cylindrical kathode beam bent into a circular arc by means of a strong magnetic field. In the original calculation only the curvature of the part of the beam adjoining the kathode was taken into account, although it increased further off. Allowing for this fact, and also for an increase in the potential-gradient, values are obtained which more closely agree with those of Kaufmann. Further experiments show that when the diameter of the ring is lessened, either by diminishing the potential-gradient or by increasing the strength of field, the quantity e/m is apparently increased. Still, Kaufmann's theory of the magnetic deflection is incomplete, and is only capable of indicating a superior limit of the ratio e/m. In Thomson's and Lenard's experiments no assumptions are made concerning the ratio of the velocity to the potential-gradient, but the calculations are based upon electrostatic repulsion. Lenard finds a mean value of $6{\cdot}4 \times 10^6$, and J. J. Thomson $7{\cdot}4 \times 10^6$. These are about midway between those found by the author and by Kaufmann respectively. These values are probably vitiated by the uncertainty as to the actual constitution of the gas in the tubes, which has a considerable influence upon the potential-gradient. It is interesting to note that Lorentz's value, deduced from Zeeman's experiments, is 10×10^6. This would indicate an equality between the particles producing luminous vibrations and kathode rays respectively, which would be of supreme theoretical importance. E. E. F.

1348. *Waves in a Medium of Periodic Discontinuity.* **H. Lamb.** (Mem. Manchester Lit. & Phil. Soc. 42. 3. pp. 1–20, 1898.)—The main object of this paper is to illustrate the selective total reflection which takes place at the boundary of a medium of the above constitution. In the examples chosen for discussion, the medium is represented by a string supposed to be capable of longitudinal vibrations, and the periodic interruption of properties consists, in one case, of a series of equal particles attached at equal intervals; in another, these particles are urged towards fixed positions by elastic springs; whilst in a third example they are supposed to be connected to the string through the intermediary of springs. It is further shown how the methods can be extended to the case where equal and similar dynamical systems, of any degree of complexity, are inserted at regular intervals. The same analysis applies when the intervening medium consists of a tense string capable of transversal vibrations and to many other cases.

The case where the masses have an elastic connection with the vibrating string appears to illustrate the theory of refraction sketched by Sir G. Stokes in the 'Wilde Lecture' for 1897. At all events, the analysis shows that the one-dimensional medium under discussion has the following characteristics:—

(1) It possesses for sufficiently long waves a definite index of refraction, with coefficients of reflection and transmission related to this index in the usual manner.

(2) It totally reflects radiations of wave-lengths lying between certain limits.

(3) For sufficiently short waves it allows, as a rule, free transmission, with practically no reflection. E. H. B.

1349. *Measurement of Hertzian Oscillations.* **A. Ekström.** (Annal. Phys. Chem. 64. 2. pp. 315–324, 1898.)—When an electric oscillation is propagated along a wire reflections take place at each end of the wire, and the interference-curve obtained by taking electrometer or bolometer measurements at each point on the wire is usually a complex one. The author shows that if the wire be a long one, the interference-curve at a great distance from the oscillator has the same form as the primary oscillation. With shorter wires of variable length the form of the interference-curve depends on the length and contains harmonic overtones in addition to the fundamental oscillation. Four types of interference-curve are given, to one or other of which the curves found by different physicists belong. J. L. H.

1350. *Influence of Frequency upon Capacity.* **J. Hanauer.** (Annal. Phys. Chem. 65. 4. pp. 789–814, 1898.)—Both in solids and in semi-conducting liquid dielectrics the capacity of a condenser varies with the frequency of the alternate current used. In the solid dielectrics a loss of energy occurs at the same time, which increases with the period and with the variation of capacity. The phenomenon appears to be connected with residual discharge, and an explanation must be sought in a lack of homogeneity in the dielectric. In liquids the change of capacity with frequency is considerably reduced by platinising the condenser-plates. Calculation shows that polarisation must exert an influence upon the capacity of a liquid condenser. Probably, therefore, polarisation accounts for the observed variation, and we have here no phenomenon of electric dispersion. E. E. F.

1351. *Thermal Phenomena in Condenser Circuits: Part I., Electrolytes.* **P. Cardani.** (N. Cimento, 7. pp. 23–45, 1898.)—The resistance of a metallic conductor is greater for alternating currents of high frequency than for steady currents, because in the former case the current tends to keep to the surface of the conductor. Stefan has shown that theoretically no such difference ought to exist in electrolytes, the distribution of current throughout the section of the electrolyte being the same for all frequencies. The author describes experiments which confirm the theoretical deductions of Stefan. A circuit is arranged containing a condenser, a platinum wire enclosed in the bulb of a petroleum thermometer, and a spark-gap similarly enclosed in an air-thermometer; the circuit also includes a tube of the electrolyte of variable length and cross-section. In the experiments the self-induction of the circuit and the length of the spark-gap are kept constant, and the change of thermometer-reading produced by twenty condenser discharges is observed for columns of electrolyte of varied length, cross-section, and material, correction being made for radiation from the surface of the thermometer. The results show that the resistance of a column of electrolyte of length L and sectional area S, is KL/S, the value of the specific resistance K being the same for the condenser-discharges as for steady currents. The experiments suggest a new method of measuring electrolytic resistance, which is free from many of the inconveniences of the present methods. J. L. H.

1352. *Resistivity of Steels.* **H. Le Chatelier.** (Comptes Rendus, 126. pp. 1709–1711, 1898.)—The specimens of steel experimented on were in the form of bars 20 cms. long and 1 cm. square; they were annealed several hours at 600° C. In the following table the numbers express the specific resistances in microhms per centimetre cube:—

Influence of Carbon.

Resistance.	Composition.		
	C.	Mn.	Si.
10	0·06	0·13	0·05
12·5	0·20	0·15	0·08
14	0·49	0·24	0·05
16	0·84	0·24	0·13
18	1·21	0·21	0·11
18·4	1·40	0·14	0·09
19	1·61	0·13	0·08

The resistance clearly increases with the amount of carbon, its increase is on an average 7 microhms for one per cent. of carbon by weight, or 1·5 microhm for one atom of carbon per 100 atoms of iron and carbon.

Influence of Silicon.—An increase of 14 microhms for 1 per cent. of silicon by weight, or 7 microhms for one atom of silicon per 100 atoms of alloy. The author is lead to the conclusion that in steel the silicon is not isolated in the form of a definite silicide $FeSi_2$, but is found in the form of a homogeneous mixture, solid solution, or isomorphous mixture.

Influence of Manganese.—Manganese considerably augments the resistance of steel. This metal, isomorphous with iron, forms with it homogeneous mixtures in all proportions. These mixtures can, however, exist in two allotropic states, unequally magnetic and also possessing resistances notably different. The experiments show an increase of resistance about 5 microhms for 1 per cent. of manganese by weight or in atoms for the non-magnetic alloy. For the magnetic (obtained by annealing 2 hours at 550°) this increase of resistance is only 3·5 microhms.—The paper also deals with the influence of nickel, chromium, tungsten, and molybdenum. E. C. R.

1353. *Effect of Tempering on Resistivity of Steel.* **H. Le Chatelier.** (Comptes Rendus, 126. pp. 1782–1785, 1898.)—Tables are given showing the increase of resistance after tempering at various temperatures, ranging from 710° to 1100°; the samples tested were 2 ordinary steels, 4 tungsten steels, and 3 chrome steels. At high temperatures chromium adds to the increase of resistance due to the carbon alone; tungsten, on the other hand, diminishes it. In all cases the resistance increases with the increase of the temperature up to a limiting value depending on the constitution of the steel. G. B. M.

1354. *High Pressure Experimental Battery.* **A. C. Longden.** (Elect. World, 31. p. 681, 1898.)—A high-pressure battery may be formed of zinc and copper couples, which are dipped into water just before use; but the internal resistance is very high. If acid is used, local action is troublesome. The author overcomes these difficulties by using, in place of zinc, copper amalgamated with zinc amalgam, the plates being allowed to stand in a small quantity of zinc amalgam at the bottom of the cell. A compact battery may be made out of small homœopathic vials which, when charged with one-per-cent. acid, gives no trouble and has a comparatively small internal resistance. W. R. C.

1355. *Standards of E.M.F.* **W. Jaeger** and **K. Kahle.** (Annal. Phys. Chem. 65. 4. pp. 926–942, 1898.)—Standards of E.M.F. offer a ready and accurate means of producing a standard current, although in the last instance a silver voltameter has to be called into use. But with the latter it is difficult to attain an accuracy of 0·01 per cent., whereas that is easily attained by a combination of the Clark and the Weston cells. Such a combination furnishes more than twice the security of a single cell, since not only the constancy of the two elements separately but also the constancy of their ratio may be treated. If, besides the constant differences between two elements of the same kind, this ratio also remains constant, it may safely be assumed that the cells themselves have remained constant. To establish this conclusion, the authors have determined the E.M.F. of a large number of zinc and of cadmium standard cells of various ages with the aid of the Reichsanstalt silver voltameter, and have redetermined the temperature coefficients of both the standard cells. Out of 27 Clark cells constructed since 1891, one showed a decrease in the E.M.F. of 0·14 millivolt in one year. Out of 41 Weston cells, one showed an increase of 0·18 millivolt in two months. These were the maximum variations. In the case of the cadmium cell referred to, the excess fell to 0·08 millivolt in three years after construction. The values as redetermined are:—

E.M.F. Clark cell .... 1·4328 intern. volts at 15° C.
„ Weston cell .. 1·0186 „ „ 20° C.

Temperature coefficient of Clark cell:

$$= -0{\cdot}00119\,(t-15) - 0{\cdot}000007\,(t-15)^2.$$

Temperature coefficient of cadmium cell:

$$= -0{\cdot}000038\,(t-20) - 0{\cdot}00000065\,(t-20)^2.$$

E. E. F.

1356. *Reactions in Accumulators.* **G. Darrieus.** (Écl. Électr. 14. pp. 141–155, 229–237, 370–374, 498–503, and 555–561, 1898.)—These papers are the result of an experimental study of accumulators, chiefly of the lead type. By means of analysis after charging and again after discharging, the author arrives at the following conclusions, chiefly in opposition to the double sulphate theory. Persulphuric acid is immediately formed as soon as charging begins, and its appearance is more marked the stronger the sulphuric acid. The active matter on the positive after charging is simply PbO_2, and on the negative spongy lead containing traces of free hydrogen. After discharge, the amount of PbO_2 reduced depends on the number of ampere-hours of discharge, but this is not true of the amount of sulphate formed. On the other hand, the lead sulphate formed on the negative is proportional to the ampere-hours of discharge. If sodium-sulphate solution is substituted for the sulphuric acid in a charged cell which is subsequently discharged, it is found that only a trace of sulphate is formed on either plate, and when the negative active material after this discharge is heated in a gas flame it becomes incandescent, giving a mixture of litharge and metallic lead. From this it is inferred that the reaction at the negative is simply one of oxidation, the sulphating being due to a secondary reaction. Partial discharge may be brought about by allowing the negatives to oxidise in the air. With regard to the positives it would appear that the PbO is simply the depolariser, being reduced to PbO, which is then converted into sulphate by local action between PbO_2 and PbO. The action of persulphuric acid in charging is necessary as an oxidant. The preceding remarks relate to the flat parts of the charge and discharge curves; the steep parts are fully accounted for by the presence of persulphuric acid and free hydrogen. The E.M.F., as calculated from Kelvin's law, is shown to practically agree with the experimental value, if it is allowed that the spongy lead is in a different molecular state to the ordinary metal.—The author then passes on to further experimental proofs. Oxides lower than PbO_2 are capable of existing in dilute sulphuric acid. The rapid rise of E.M.F. at the end of a charge is due to the formation of exothermic bodies, and not to unequal density of acid about the plates as contended by Gladstone and Hibbert. The amount of acid held by either plate is found to be about the same. Experiments with artificial positives made out of mixtures of PbO_2 and PbO, or PbO_2 and $PbSO_4$, show that the discharge curve closely approximates the usual form in the case of the latter, and that only 15 °/₀ of PbO_2 (chemically formed) is necessary in this mixture to give an E.M.F. of 1·99 volts. It is thus desirable to facilitate the local action on the positive. The ideal plate should consist of molecules of peroxide, each with a conducting molecule alongside. Local action on the negative is, of course, to be avoided. Amalgamation of these raises the E.M.F. by 0·11 volt, increases the capacity and diminishes local action; but these results are not permanent. Disintegration of positives is more probably due to liberation of oxygen in charging than to changes of volume. The author concludes with experiments on aluminium, antimony, copper, and platinum, used as plates, the results of which have a bearing upon the double sulphate theory. Many interesting experiments are described which cannot be included in a short abstract. W. R. C.

1357. *Lead Accumulators.* **F. Dolezalek.** (Annal. Phys. Chem. 65. 4. pp. 894–916, 1898.)—A paper on the same lines as that noticed in Abstract No. 689. E. E. F.

1358. *Aluminium Electrodes in Electrolytic Cells.* **E. Wilson.** (Roy. Soc. Proc. 63. pp. 329–347, 1898.)—In Part I. aluminium-carbon cells are experimented upon with direct currents, the electrolytes being alum solution, dilute H_2SO_4, and aqueous NaOH. For the purpose of allocating the distribution of potential-difference in the cell an exploring electrode was placed between the plates. After establishing the well-known effect, that it is between the electrolyte and aluminium when used as an anode that the apparent great resistance takes place, a series of experiments were made to find the effect of variation of current-density and temperature upon the potential-difference between the plates. With the temperature rising from 13° to 20° C., and a variation of current-density from ·00011 to ·04 ampere per square inch of Al anode the potential-difference rose in alum from 1·9 to 34·5 volts. With approximately constant current-density of ·019, the potential-difference fell from 30 to 3 volts as the temperature of the cell rose from 13° to 70° C. No material increase of potential-difference was found on cooling the cell by freezing. A microscopic examination and chemical analysis, by H. Jackson, of one of the films formed on the Al plate, show that it is full of minute cracks giving the impression of a dried gelatinous pellicle, not unexpected if the plate had been covered when wet with gelatinous aluminium hydroxide. The analysis shows the film to consist of basic aluminium sulphate. An experiment was made upon a film formed without the passage of current, by first submerging a bright Al plate in alum solution, and then exposing it to the atmosphere. The conclusion is that this film has the same effect as another formed during the passage of current. Such a film when dry had an electrical resistance of about 10,000 ohms.

In Part II. the subject of Alternate Currents is dealt with. Experimenting first with aluminium and carbon plates in alum solution, the frequency was varied from 16 to 98 periods per second, and the current-density varied from ·04 to ·58 ampere per square inch of the Al plate. The result is that large phase-difference between current and potential-difference occurs with the small current-densities; but a large ratio between the maximum coulombs in the halves of a period, which is the effect looked for, has not time to properly develop with the frequencies mentioned. It is shown that a uni-directional current can be obtained by an arrangement of these cells proposed by Graetz, and the efficiency is discussed. The concluding experiments deal with the suitability of aluminium when forming the plates of condensers for alternate currents. Soda, ammonia, and potash alum solutions, when saturated and non-saturated, were employed as electrolytes. The current-densities were varied from ·014 to ·6, and the frequency from 7·5 to 100. Phase-differences of the order of $\frac{1}{8}$th period can be obtained by a suitable choice of current-density and temperature.

AUTHOR.

1359. *New Absolute Electrodynamometer.* **M. Deprez.** (Comptes Rendus, 126. pp. 1608–1610, 1898.)—Let a perfectly regular coil, of any number of layers, be wound solenoidally upon a tore of revolution. Inside the tore place a circular cylindrical coil, movable about an axis of rotation which is in the diametral plane of the tore, and perpendicular both to the axis of the tore and to the axis of the cylinder; and let the axis of rotation pass through the centre of the cylinder. When the axis of the cylinder is parallel to that of the tore, and currents I, I′ are sent through the coils, the couple on the inner coil about the axis of rotation is rigorously $2NII'\Sigma(S)/a$, where $\Sigma(S)$ is the sum of the areas enclosed by the turns of the movable coil; N the number of turns wound on the tore; and a the distance of the centre of the movable coil from the axis of the tore.

G. B. M.

1360. *Guye's Electrostatic Wattmeter.* (Écl. Électr. 15. pp. 114-115, 1898.)—The needle turns on knife-edges in a vertical plane and consists of two aluminium semicircles, having their diameters horizontal, fixed into an ebonite piece which insulates them one from the other and carries the knife-edges. The pointer is attached to the upper semicircle, and a rod, with adjustable weight providing the controlling force, to the lower. This needle swings between two pairs of fixed semicircular brass plates, the pairs being separated along the vertical; the distance between the two plates of each pair can be adjusted by means of distance pieces slipped over their screwed supports. The two main circuit terminals are connected to these two pairs, and the two semicircular sectors of the needle are connected to the ends of a non-inductive resistance carrying the current. G. H. BA.

1361. *Alternate Current Wattmeter.* **H. Behn-Eschenburg.** (Ann. Ass. Suisse Électr. 8. pp. 43-51, 1897.)—The wattmeter is on the principle of the d'Arsonval galvanometer, the fixed magnet being energised by the main current, and the moving coil taking current from a shunt across the mains. The axis of the moving coil is perpendicular to the plane of the horseshoe fixed magnet. The shunt consists of an inductionless resistance, one end joined to one main, the other to two resistances in parallel; of these, one is inductionless and completes the circuit directly to the other main, and the other is inductive and completes the shunt circuit through the moving coil. The object of the small inductive resistance inserted in series with the moving coil is to balance the effect of the hysteresis in the main circuit. The latter produces a phase-difference of about 5°, and by suitably adjusting the inductance of the shunt-circuit, according to calculations given in the paper, a similar phase-difference is created in the shunt-circuit and the effect of hysteresis balanced at any frequency. G. H. BA.

1362. *Correction Factors of Wattmeters.* **M. Aliamet.** (Électricien, 15. pp. 386-389, 1898.)—The author shows by simple graphical methods that a wattmeter whose thin coil has sensible reactance always gives incorrect readings, even if it is carefully standardised, unless the reactances of the thin coil and the main circuit including the thick coil are equal and opposite. The readings are of course correct if the reactance of the thin coil is zero.
W. G. R.

1363. *Coherers.* **L. Arons.** (Annal. Phys. Chem. 65. 3. pp. 567-571, 1898.)—Coherers were prepared by cutting a fine line across a thin strip of tinfoil stuck on glass, laying a little metallic powder over it, adding a drop of Canada balsam, and covering it with a cover-glass. In this manner the whole field of action could be brought within the range of the microscope. The Canada balsam did not interfere with the efficiency of the coherer, a fact which gives some idea of the energy of the reaction. The newly prepared coherers had an infinite resistance. On exposing them to the impact of electric waves full contact was as a rule immediately produced, especially when the particles were at all dense. Under the microscope violent commotions and a play of sparks were observed among the particles. The green sparks between silver particles were specially bright. Usually the contact could be annulled by tapping. Sometimes, especially in the case of brass filings, one or two particles would stick on hard, and their surfaces showed signs of oxidation. They had to be removed by a brush. When the particles were embedded in Canada balsam, a light pressure on the cover-glass sufficed to annul the conductivity. A peculiar phenomenon observed was the destruction of contacts by a repetition of the vibrations which produced them. The liquid of the embedded coherers was found to contain minute bubbles after reaction. The author exposed a particularly clean cut 0·019 mm. wide to waves without powder. A number of small sparks were seen to play between the edges, and the interval became covered with a fine brown deposit. The tinfoil appeared somewhat frayed. This experiment makes it very probable that in some cases, at all events, the reaction of the coherer is a purely electrical process. E. E. F.

1364. *Applications of the Coherer.* **O. Leppin.** (Annal. Phys. Chem. 65. 4. pp. 885–889, 1898.)—The author confirms Auerbach's observations concerning the influence of sound-waves upon the resistance of coherers. The influence depends upon the pitch of the sound. The Branly coherer used contained copper filings. It was placed in the focal line of the Hertzian mirror. Of some twenty organ-pipes, only one produced a deflection; but this deflection was not less than that due to electric waves, and was obtained even at a distance of 20 m. At some distances the deflection failed, and experiments proved that in those cases the coherer was situated at a node. The coherer also acts as a microphone and as an indicator of heat- and light-waves. The experiments quoted are, however, not conclusive for proving that light operates except by its heating effects. E. E. F.

1365. *Oscillatory Currents.* **E. F. Northrup.** (Elect. World, 31. pp. 674–676 & 710–711, 1898.) [See Abstract 946.]—The special application of the author's high-frequency apparatus to Röntgen-ray work is considered; and a method is described of regulating the vacuum of Röntgen-ray tubes, and hence the penetrative power of the rays given off by them. Some of the more striking phenomena of high-frequency currents are next described, more particularly those illustrating the enormous importance of impedance as against simple resistance. The powerful electromagnetic and electrostatic induction-effects due to high-frequency currents are next illustrated by some experiments, and their application to a system of wireless telegraphy tried by the author is explained. A. H.

1366. *Measurement of Phase-difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 322–333, 1898.) [See Abstract No. 797.]—Besides the method involving the use of a pencil of kathode rays, the author suggests the use of a light metallic spherical shell suspended at the centre of the system of conductors (shown in fig. 2, Abstract 797). In general, before any adjustment has been attempted, the resultant field is an elliptic one. Now such a field may be regarded as due to the superposition of a simple alternating field whose direction is that of the major axis of the ellipse on a rotating circular field whose intensity is proportional to the minor axis. Since a simple alternating field exerts no couple on a conducting spherical shell, it follows that the maximum couple will be obtained when the resultant field is circular. Accordingly the angles ψ_1 and ψ_2 must be adjusted until the conducting shell gives the maximum deflection. This method would not, however, in many cases be of sufficient delicacy. A small test-coil, of a sufficiently large number of turns, may then be placed at the centre of the conductors and connected to an extremely sensitive electrodynamometer (one of the Bellati type). The author describes a special form of apparatus designed for use with such a search-coil, and by means of which the adjustments required for the determination of the phase-difference may be made in a rapid and systematic way. Finally, the author considers the condition of equilibrium of the movable portions of the conductors in fig. 2 when these are delicately suspended or pivoted, and from this deduces another method of arriving at the phase-difference. A. H.

1367. *Electromagnetic Screening.* **L. Arons.** (Annal. Phys. Chem. 65. 3. pp. 590–594, 1898.)—Gives the elementary treatment of a simple case of electromagnetic screening, in which the influence of the changed conductivity of a neighbouring conductor and the difference in behaviour during periodic and aperiodic change of the magnetic field are embodied in manageable formulæ. E. E. F.

1368. *Magnetic Tests by d'Arsonval Ballistic Galvanometer.* **S. Sheldon** and **T. Cocks.** (Elect. World, 31. p. 735, 1898.) —The authors first investigate the throw per microcoulomb of a d'Arsonval ballistic galvanometer of 1030 ohms resistance and 11 seconds period with various resistances in the external circuit. They find the throw varies from 80 divisions to 132, as the external resistance is increased from zero to 10,000 ohms. If the calibration of the galvanometer is made by the earth-inductor method the standard solenoid method, or the time of oscillation and logarithmic decrement method, the resistance external to the galvanometer can be easily made of any magnitude. If the calibration be made by the much more convenient standard cell and condenser method, it is necessary to make use of a double-tongued key or equivalent device. Such a key has an upper and lower contact. In operation it charges a standard condenser from a standard cell, discharges it through the galvanometer, and then immediately closes the galvanometer through a resistance that can be adjusted at pleasure. To prove experimentally that concordant results would be obtained irrespective of the resistance of the galvanometer-circuit, so long as the corresponding constants were employed, a test ring was subjected to a constant magnetising force of such a magnitude as to bring the induction up to the knee. The magnetising current was reversed, and the induction calculated from the throw. This was repeated with various resistances from 0 to 10,000 ohms in the galvanometer circuit; the values for the induction agree within the limits of experimental error. A further test was made by measuring the hysteretic constant of a sample of iron known to have considerable hysteresis; by obtaining the B-H curve in the usual manner, the value obtained was $\eta=0{\cdot}0039$. η was also measured by the wattmeter method, using a wattmeter, a Cardew voltmeter, and a Hartmann & Braun hot wire ammeter. The result obtained was $\eta=0{\cdot}0043$. The authors consider the difference between these two values as probably due to a viscous hysteresis or magnetic creeping which goes on during the interval between the successive observations of the step-by-step process. This would make the area of the hysteresis-loop smaller than if the cycle were accomplished in a fraction of a second. The authors conclude that the results obtained from a d'Arsonval ballistic galvanometer, when properly manipulated, are to be relied on. Furthermore, a d'Arsonval galvanometer which is quite heavily damped, which is of low resistance, and which has a time of oscillation as small as one second, can be made to give accurate results. E. C. R.

1369. *Electromagnet for High Induction.* **P. Weiss.** (Écl. Électr. 15. pp. 481–487, 1898.)—The magnet is in the form of a rectangle, of which three sides are formed of a single piece of forged iron, the middle part being cylindrical and of 7 cm. diameter and 32 cm. long. In the side parts slide two cylindrical cores of the same diameter; they are threaded at their external ends, and can be moved either way independently of one another by means of two small bronze wheels forming nuts on them, working similarly to the poppet of a lathe. The cylindrical cores can be fitted with various pole-pieces, either flat or truncated cones. The coils are carried by the movable cores, and the side of the rectangle parallel to them, the bobbin covering the latter consisting of 2200 turns of wire 2 mm. in diameter. The cores have each a bobbin of 600 turns, between which there remains a free space of 9 cm. Two supplementary bobbins of 200 turns each can be placed in this space over the poles. The bobbins will carry a current of 9 amperes for 2 hours, or 14 amperes for 10 minutes without over-heating, giving, with the supplementary coils, 32,000 and 50,000 ampere-turns respectively. The total resistance is about 9 ohms, and for the maximum current requires 125 volts and absorbs 1·75 kilowatts. With conical pole-pieces (the half-angle at the apex of the cone being 63½°), truncated to a diameter of 1 cm., placed 5 mm. apart,—

Current = 2·7 amperes.	H = 19,000
8·9 ,,	26,000
11·7 ,,	26,600
14·3 ,,	27,300

With a current of 11·4 amperes, the same pole-pieces give

Distance apart.	
5 mm.	H = 26,500
3·5 ,, ...	29,500
2 ,, ...	30,500

E. C. R.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1370. *Companions of Argon.* **W. Ramsay** and **M. W. Travers.** (Roy. Soc. Proc. 62. pp. 316–324, & 63. pp. 437–440 1898.)—In earlier papers (C. R. 123. p. 214, mentioned in Phys Soc. Abstracts, No. 779, 1896, and Roy. Soc. Proc. 60. p. 206), a description was given of attempts to separate argon and helium into portions of different densities by diffusion,—when they met with partial success only in the case of helium. In the first of the present papers a figure and description is given of a larger and improved apparatus. In the case of air as a test, a fairly rapid separation of O_2 and N_2 was effected. Nitrogen prepared from ammonium chloride proved to be homogeneous as regards the relative density of its individual molecules. Helium from samarskite and cleveite was subjected to a very large number of fractionations. Small quantities of nitrogen and of argon were separated, but no unknown gas. It is incidentally mentioned that helium is inodorous and tasteless, has a density of 1·98, a refractivity of 0·1238, and a probable atomic weight of 4.

In the second paper argon is re-investigated by fractional distillation. Eighteen litres were prepared from air by absorbing the O_2 by copper and the N_2 by magnesium. By means of liquid air boiling under reduced pressure, 13 to 14 litres were liquefied in a small bulb. A considerable quantity of a *solid* was seen to separate in the liquid and round the sides. By exhaustion two fractions, forming 50 or 60 c.c. of gas, were distilled into gasometers; the density was found to be 17·2. The first fraction was mixed with O_2 and sparked over soda. After removal of the O_2 by phosphorus, the density of the residual gas was 14·67, and the spectrum showed, with other lines, a brilliant yellow one of wave-length 5849·6; therefore not identical with those of sodium, helium, or krypton. Unlike these elements it was rapidly absorbed by the red-hot aluminium electrodes of a vacuum-tube, and the appearance changes as the pressure falls from fiery red to a most brilliant orange, which is seen in no other gas. The name *neon* is proposed. Its position in the periodic table would require a density of 10 or 11, which may probably be reached by further fractionation.

The remaining argon was now distilled off, and the jacket removed. On slightly raising the temperature the solid was seen to melt, and was distilled into a separate gasholder. Its density was found to be 19·87. The spectrum was very complex and differed entirely from that of argon. The measurements are given. Its wave-length for sound proves it to be monatomic. The authors propose the name "metargon." Krypton did not appear in the higher boiling fraction. S. R.

1371. *Krypton.* **W. Ramsay** and **M. W. Travers.** (Roy. Soc. Proc. 63. pp. 405–408, 1898.)—750 c.c. of liquid air were allowed to evaporate slowly, till 10 c.c. were left. This residue was distilled into a gas-holder: after removal of O_2 and N_2, and after sparking with O_2 over soda, 26·2 c.c. were left of a gas almost free from argon and showing a new spectrum with two very brilliant lines almost identical with D_3. The specific gravity is 22·47. The wave-length of sound shows it to be monatomic.

S. R.

1372. *Helium, Argon, and Krypton in the Periodic System.* **W. Crookes.** (Roy. Soc. Proc. 63. pp. 408–411, 1898.)—Some years ago the author constructed a model illustrating in three dimensions his rearrangement of the periodic table. The present paper describes and figures a new edition of the model (founded on a "figure of eight") which includes the recently discovered elements, about whose position there has been so much difficulty. Electro-positive elements are disposed on one side of the figure, negative on the other, valency is governed by distance from centre, and other properties depend similarly on position. S. R.

1373. *Ionisation by the Boiling-point Method.* **H. C. Jones** and **S. H. King.** (Chem. News, 77. pp. 243–244, 1898, and American Chemical Journal, 19. no. 9.)—The authors draw attention to the value of the boiling-point method for the determination of ionisation in solvents having but small ionising power. This method has not been much used owing to want of accuracy. The authors have obtained good results by using a modified Beckmann apparatus in which the thermometer is surrounded by a platinum cylinder: this cuts off radiation and prevents the condensed solvent from coming in contact with the thermometer until it has been reheated. Results are given for potassium iodide and sodium acetate in alcohol. W. R. C.

1374. *Molecular Weights by Vapour Pressures.* **W. R. Orndorff** and **H. G. Carrell.** (Journ. Phys. Chem. 1. pp. 753–759, 1897.)—The authors used the method of Will and Bredig, but discarded their water-bath. Although by so doing variations of temperature amounting to several degrees were sometimes introduced, the results were found to be equally good. Passing the air through the solvent first, and then through the solution, was not found to be so successful as the reverse method. Certain details, which are described, should be attended to in order to ensure success. Bulbs, though plugged, were found to lose over 10 milligrammes in twenty-four hours; the time of an experiment should therefore be reduced as far as possible. The results are generally found to vary with the rate at which the air is passed, and there is one rate which is the best. In calculating the results the formula $M=46gs'/100s$

was used, in which M is the molecular weight, g the weight in grammes of solute in 100 of the solvent, s the loss in the solvent bulbs, s' that in the solution bulbs, and 46 is the molecular weight of alcohol used as solvent. The results vary considerably in value. For urea (mol. wt. 60) under various conditions the figures obtained were 55, 46, 62, 51, and 70. W. R. C.

1375. *Molecular Depression of Freezing-point.* **M. Wildermann.** (Zeitschr. Phys. Chem. 25. 4. pp. 699–721, 1898: see also Transactions of the Chem. Society, 1897.)—The author has determined the molecular depression of the freezing-point of water produced by acetone, aniline, dextrose, and phenol. The method used is that described previously. The convergence temperature is below the freezing-point of the solution, and different parts of the scale of the thermometer (graduated to $\frac{1}{1000}$°) are used, giving mean differences of 1 or 2 °/$_0$. Further results are also given for several other substances, tabulated below:—

Substance.	Molecular depression.
Acetone	1·82 to 1·85
Aniline	1·83 to 1·85
Phenol	1·82 to 1·83
Dextrose	1·85 to 1·87
Urea	1·87 to 1·89
Maltose	1·84
Milk-sugar	1·85 to 1·88

A further set of determinations of the freezing-points of solutions containing urea and resorcinol, cane-sugar and urea, dextrose and urea, and alcohol and urea, shows that the law that in very dilute solution each substance exercises its influence on the freezing-point independently of the other is true within the limits of experimental error. T. E.

1376. *Electric Osmosis and Electro-stenolysis.* **A. Coehn.** (Zeitschr. Phys. Chem. 25. 4. pp. 651–656, 1898.)—The author has shown (see Abstract No. 505, 1898) that bodies of higher dielectric capacity assume a positive charge in contact with bodies of lower dielectric capacity. The explanation of electrical osmosis given by Helmholtz assumes the formation of an electrical double-layer, one side of which is on the wall of the capillary passage (say a crack in a glass tube immersed in the liquid), the other on the liquid filling it. If the liquid is water, it will, owing to its high dielectric constant, be positively charged. If electrodes be placed, one within the glass tube, the other without it, the positive charge on the water in the crack will be displaced towards the negative electrode, leaving a negative charge on the glass. If the water contains a salt, say copper sulphate, in solution, the Cu ions will be drawn to the glass wall, their electrical charges neutralised and separated out in the metallic state. The SO_4 ions may be similarly neutralised by the electrostatic positive charge on the water, giving dissolved oxygen and sulphuric acid. The very minute metallic deposit thus formed will act as an intermediate conductor with anodic and kathodic ends and can only increase to visible dimensions if—(*a*) the negative radicle separated at the anode does not dissolve the metal; (*b*) an insoluble substance separates at the anode; (*c*) the negative radicle combines with the salt in the solution. Salts which come under one or other of these headings should exhibit the phenomenon to which Braun has given the name of Electrostenolysis, namely, the deposition of a metallic or other deposit on the walls of a fine crack in a glass wall which is placed between two electrodes in the solution of an electrolyte. A critical survey of Braun's results shows that this conclusion is in the fullest agreement with the facts. T. E.

1377. *Diffusion through Gelatine.* **A. Hagenbach.** (Annal. Phys. Chem. 65. 4. pp. 673–706, 1898.)—Various gases are enclosed in a vessel under constant pressure which is separated from another vessel by a wooden plate containing a large number of holes filled with gelatine. The transfusion through the gelatine is used for determining the coefficients of diffusion of the gases. The amount in c.c. of the various gases traversing in one day a cube of 20 per cent. gelatine is 0·845 in the case of CO_2, 0·509 for N_2O, 0·0565 for H, 0·230 for O, and 1271 for ammonia, at 17° C. The vapour-tension of gelatine is about the same as that of water. The absorption of gases in gelatine is hardly different from that in water, but the diffusion-coefficients are smaller in gelatine. Exner's rule, according to which the volumes of gases exchanged are as the absorption-coefficients, and inversely proportional to the square roots of their densities, is only approximately verified. E. E. F.

1378. *Hydrolytic and Electrolytic Dissociation.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 23–27, 1898.)—The author considers the process of solution and its connection with electrolysis from the point of view of the chemist, and contrasts the conceptions of hydrolytic and electrolytic dissociation. We are indebted to electrolytic theories for the introduction of the idea of dissociation as affording an explanation of certain physical facts, but it is questionable whether this dissociation takes place exactly as supposed. Chemical facts are, it is claimed, in favour of the hypothesis of hydrolytic dissociation, with which the electrolytic theories should, by suitable modifications, be brought into agreement. J. W.

1379. *Electrolysis of Calcium Chloride Solutions.* **F. Oettel.** (Zeitschr. Elektrochem. 5. pp. 1–5, 1898.)—Experiments made by the author some years ago, the publication of which has been delayed, are in full accordance with the results of Foerster and

Bischoff (see Abstract No. 830). The formation of a membrane of precipitated lime round the kathode is confirmed, and its efficiency is stated to be independent of its thickness. An attempt was made to devise a continuous process by adding potassium chloride to an electrolysed solution of calcium chloride, then separating the sparingly soluble potassium chlorate, and again submitting the regenerated calcium chloride to electrolysis. It was found, however, that the presence of potassium chloride in the solution caused the precipitation of hard, thick crusts of lime with simultaneous liberation of free chlorine. This may sometimes be remedied by addition of free lime, but the effect of this is very variable. By cooling an electrolysed solution of calcium chloride, long, hard needles of an oxychloride of calcium were obtained, and it is supposed that this substance may play an important part in the process. Accidental contamination of the electrolyte with salts of copper from the connections was found to cause decomposition of the hypochlorite, with evolution of oxygen. Oxides of iron, copper, lead, nickel, and, as is well-known, cobalt, have the same prejudicial effect. The author considers electrolytic formation of chlorates to take place in two ways: (1) by conversion of the hypochlorite first formed into chlorate; (2) by direct combination of chlorine and oxygen during their simultaneous liberation at the anode. The first reaction predominates in neutral, and the second in alkaline solutions. J. W.

1380. *Most Economical Current in Electrolysis.* **Vogel.** (Écl. Électr. 16. p. 116; from 'Theorie elektrolytischer Vorgänge,' pp. 109, 110).

If i_0 = current density per sq. metre;
q = superficial area of anode or kathode in sq. metres;
i = the intensity of the current;

then $i = i_0 q$.

If l = distance separating the electrodes in centimetres;
a = spec. resistance of the electrolyte;
r = resistance of the cell, neglecting that of the electrodes;

then $$r = a\frac{l}{q \times 104}.$$

If e = back E.M.F. of the cell;
t = number of working hours per year;
T = work performed;
then $T = i(e + ir)t$ or $i_0 qt(e + i_0 al)$.

If g = the electrochemical equivalent of the body deposited, the weight deposited in one year will be $= git$ or gi_0qt, and the work required to deposit unit weight of the substance will be

$$= \frac{T}{gi_0qt} \text{ or } \frac{1}{g}(e + i_0 al).$$

If P=the cost of a unit of electrical energy delivered at the terminals of the cell, the cost of the energy requisite to deposit unit weight of the substance will be

$$\frac{P}{g}(e+i_0 al). \quad \text{(I)}$$

The cost of the electrolytic cell may be taken as proportional to the superficial area (q) of the electrodes, and to the price (n) of 1 c.cm. of the kathode material. If K be taken to represent the frequency of renewal of the cell and its electrodes, then the amount expended under this head will be $=nq \times K$ per annum, and the expenditure upon maintenance per unit weight of the substance deposited will be

$$\frac{nqK}{gi_0qt} \quad \text{(II)} \quad \text{or} \quad \frac{nK}{i_0gt}.$$

The most economical deposition evidently occurs when the sum of the expressions (I) and (II) is a minimum amount. This obtains when

$$i_0=\sqrt{\frac{nK}{Ptal}}.$$

[*Abstractor's Note.*—The 104 in the second equation is obviously a misprint for $(10)^4$, and on this account all the succeeding equations are vitiated.] J. B. C. K.

1381. *Electrolytic Refining of Tin and Treatment of Tin Ores.* **S. Cowper-Coles.** (Elect. Engin. 22. pp. 81–82, 1898.)—This article gives a description of various processes that have been tried from time to time for the electrolytic refining of tin, and also for the recovery of tin from its ores. The process of Claus, which consists in using an electrolyte of stannate of sodium or sulpho-stannate of sodium, is given as one of the most successful methods for the electrolytic refining of crude tin. Dr. Burghardt's, Classen's, Vortman & Spitzer's, and other electrolytic processes which have been experimented with for the recovery of tin from its ores, are also briefly described. AUTHOR.

1382. *Ashcroft Process for Treatment of Broken Hill Sulphide Ores.* **E. A. Ashcroft.** (Electrician, 41. pp. 554–558, 1898.)—An abstract of the paper read by the author before the Institute of Mining and Metallurgy in June. The paper deals with the trial runs of the Ashcroft process at Cockle Creek, N.S.W., in 1897 and 1898, and with the causes that had led to the failure of the process (see also Abstract No. 687). A very large number of figures were given bearing upon the costs of the thirteen separate operations incidental to the carrying out of the process. The three chief causes of failure were:—

1. Falling off in the metal contents of the ore sent to the electrolytic works for treatment by the Ashcroft process.
2. Inability to make the process truly cyclic, owing to the accumulation of manganese and other impurities in the electrolyte.
3. Lack of the funds necessary for carrying out the process upon the scale for which the plant had been designed.

The author believes that the second of these might be obviated by the adoption of a new method of treatment which he has worked out and patented, and that a profit could be earned even with the poorer ores, by working the electrolytic process in conjunction with this "oxide process" at Cockle Creek. The latter process consists in separating the zinc in the form of basic zinc sulphate from the impure electrolyte, and in roasting this to obtain zinc oxide, which is then retorted in the usual manner, in order to obtain the metal. Whereas the first hundred tons of zinc recovered at Cockle Creek cost £75 per ton, and the second hundred tons £28 per ton, the author states that with a plant designed for working the conjoint process upon the scale of 1000 tons ore per week, he could obtain a profit of 20*s.* 3*d.* per ton of ore treated, equal to £50,000 per annum profit upon a capital outlay of £250,000. J. B. C. K.

1383. *Electrolytic Extraction of Metals.* **D. Tommasi.** (Electrician, 41. pp. 591–594, 1898.)—An illustrated description of the Tommasi electrolyser. This consists of a rectangular tank, containing a circular kathode disc, revolving between two fixed anodes. The disc is only half immersed in the electrolyte; and its upper part passes between two scrapers, which serve to depolarise its surface, and also to remove the deposits of metal when spongy. When the metal is deposited in coherent form upon the kathode, a disc with removable segments is used, and the kathode is stripped by immersing any segment with its deposit, in a bath of the molten metal. The anodes may be in the form of metal plates; or coarse powder packed in perforated receptacles may be used as anode material. A detailed account of the application of this electrolyser to the desilverisation of argentiferous lead is then given. The electrolyte used consists of a mixture of lead acetate with acetate of sodium or potassium, and of some undivulged compounds in addition. Cast anodes of the argentiferous lead are used. The revolving disc may be of aluminium bronze, nickelled iron, copper, or sheet iron. It should be 3 metres in diameter, and make 1–2 revolutions per minute. The deposit will be spongy in character, and may be removed by the scrapers at intervals. The detached lead sponge is washed, pressed, and melted with 2–3 % carbon in order to obtain it in ingot form. The silver remains behind as a sludge on the bottom of the electrolyser. Theoretically no appreciable E.M.F. should be required to transfer the lead from the anode to the kathode. Practically ·75 volt is requisite. Calculations are given by the author which show that with a plant producing 25,000–30,000 tons of lead per year of 300 working days, the cost per ton with steam-power would not exceed 8·60 francs, and with water-power would not exceed 5·80 francs. Adding all incidental charges, the cost per ton should not exceed 10 francs, whereas the cost of the usual refining process is stated by the author to be 30 francs per ton. The spongy lead, instead of being melted down into ingots, may be used directly for (1) accumulator plates, (2) the manufacture of massicot, litharge, or minium, (3) the manufacture of lead carbonate. According to the author all these products can be produced much more cheaply from the electrolytic lead sponge obtained in his process than by the present processes of manufacture. J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1384. *Rowbotham Primary Battery.* (Elect. Engin. 22. pp. 139–142, 1898.)—The electrodes are carbon and iron, and the electrolyte a mixture of diluted sulphuric and nitric acid. The cell consists of two compartments, one open and the other closed. The open one contains the iron plates. The closed one consists partly of porous tubes containing the carbons in the form of rods. Water surrounds the iron plates, while the acid mixture is admitted to the closed compartments. Enough acid passes through to allow of voltaic action taking place, though not enough, it is said, to cause local action. When a current is generated gas is evolved at the carbons, and pressure is exerted in the closed compartment, thus forcing more acid into the iron compartment. On cutting off the current water flows through the iron compartment and removes the acid, thus preventing local action on standing. In a report by S. P. Thompson the cost of current is estimated at 6¼*d.* per B. T. U., excluding depreciation, interest on prime cost, and superintendence. H. T. Harrison puts the cost at 5*d.* The writer of the article disputes these figures and estimates the cost at 15·77*d.* W. R. C.

1385. *Silver Chloride Dry Cells.* (Elect. Engin. N. Y. 26. pp. 47–48, 1898.)—A description of dry cells suitable for testing, made by the Chloride of Silver Dry Cell Battery Co. W. R. C.

1386. *Application of Storage Batteries.* **J. Appleton.** (Elect. Rev. 43. pp. 353–354 & pp. 391–393, 1898.)—The saving effected in lighting and power stations by the introduction of storage batteries to take the peak of the load is discussed and the point illustrated by a description of the plant installed for running the Buffalo-street Tramways from Niagara Falls. Particulars are given of a battery claimed to be 50 °/ₒ larger than any other in the world, recently installed at Chicago. It consists of 166 cells capable of giving 12,000 amperes for 1 hour. Data are also furnished of a number of motor-cars driven by accumulators, and the arrangements of a charging station in New York for electric cabs are described. E. J. W.

1387. *Lightning and Lightning Arresters.* **H. E. Raymond.** (Elect. World, 31. pp. 713–715 & pp. 772–775, 1898.)—In these articles the author differs from Mr. Wurts, and thinks that frequently arresters of the short-gap type having a resistance in series are of more value than the non-arcing metal type. An arrester ought to act at a voltage not much greater than the working-line voltage. The gap ought to be as short as possible, but such that the current cannot follow a discharge. No swinging, fuse blowing, or mechanical devices should be used to effect this. In installing, one arrester at least should be placed so as to receive the crest of any wave liable to reach the generators, and another set placed so as to obtain the benefit derived from the natural impedance of any length of wire. A lightning arrester affords but little protection from a direct "stroke." W. G. R.

1388. *Lightning Arresters.* **A. J. Wurts.** (Elect. World, 32. pp. 5-6, 1898.)—There are two types of lightning arresters dealt with here, one using a spark-gap and a resistance in series with it, the other several spark-gaps without any resistance in series. The author is of opinion that spark-gaps without resistance in series should be used on account of the suddenness of a lightning discharge. The Fire Underwriters' rules require that lightning arresters must be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of the No. 6 B. & S. wire, which must be run as nearly in a straight line as possible from the arrester to the earth-connection. Why then put a resistance in the arrester? W. G. R

1389. *Lightning and Lightning Arresters.* **H. E. Raymond.** (Elect. World, 32. p. 73, 1898.)—The author advocates the use of an overhead barbed wire for protection against direct lightning flashes from cloud to earth, since an enormous installation of station and line arresters would be required to adequately protect any system from the effects of a very heavy "main path" discharge in close proximity to the line. Arresters form sufficient protection against inductive discharges, but not against "main-path" discharges. W. G. R.

1390. *Switchboard Construction.* **A. B. Herrick.** (Amer. Electn. 10. pp. 251–254, 1898.)—This is an article on the practical construction of switchboards for high and low tension-work, and gives important information regarding the various details which tend to diminish risk of short circuits, etc. The author considers that in the construction of arc-light switchboards marble and slate should not be depended on, and the insulation at the various points of connection should be supplemented by micanite or built-up mica. W. G. R.

1391. *Underground Conductors.* **F. A. C. Perrine.** (Elect. World, 32. pp. 69–73, 1898; also 'Electrical Engineering,' July 1898.)—This is a descriptive and critical article on the methods of laying underground cables. The methods considered are:—(1) the solid or built-in system; (2) the draw-in and draw-out system; and (3) the trench system. W. G. R.

1392. *Insulation Resistance and Leakage Currents.* **A. Russell.** (Electrician, 41. pp. 206–208, 1898.)—If the two house-mains of an electric installation be denoted by A and B respectively, there are three leakage-currents we have to measure:—(1) the direct leakage-current from the main A to "earth"; (2) the direct leakage-current from the main B to "earth"; and (3) the leakage-current between A and B which does not pass through "earth." If x, y, and a be the resistances of the paths of these currents respectively, then they can be easily determined as follows:—

(1) Measure the insulation-resistance of the main A to "earth" when B is earthed (X).

(2) Measure the insulation-resistance of the main B to "earth" when A is earthed (Y).

(3) Measure the insulation-resistance of the two mains in parallel to "earth" (F).

Then, obviously,

$$\frac{1}{x}+\frac{1}{a}=\frac{1}{X},$$

$$\frac{1}{y}+\frac{1}{a}=\frac{1}{Y},$$

$$\frac{1}{x}+\frac{1}{y}=\frac{1}{F},$$

which enable us to find x, y, and a; and hence, knowing the potential differences of the mains to earth, we can find the leakage-currents.

It is pointed out that, so far as danger from fire is concerned, it would be better to specify for a maximum permissible value for the leakage-watts rather than to fix minimum values for the various insulation-resistances. The author recommends that the leakage-watts should be measured (1) when all the switches in the house are turned off, and (2) when they are all on. He also gives a method of measuring the leakage-watts in a three-wire installation. It is proved algebraically that if F be the insulation-resistance of a three-wire distributing network, and V the potential difference between adjacent mains, then $\frac{V^2}{F}$ is the maximum possible value of the watts dissipated in earth-currents, and $\frac{V}{2F}$ is the maximum value of an earth-current. AUTHOR.

1393. *Ferrand Automatic Rheostat.* **M. Aliamet.** (Électricien, 15. pp. 337–338, 1898.)—A description is given of an automatic rheostat, the invention of J. Ferrand. A number of carbon rings are supported, in contact, upon a central insulating-rod, mounted in a frame. The mechanical pressure between the rings is adjusted by a series of levers and a variable counter-weight; the effect of the counter-weight may be diminished by an electromagnet. The electromagnet and the carbon-resistance are connected in series in the circuit where constant current is to be maintained; so that if the current tends to increase, the mechanical pressure between the carbon rings is simultaneously relieved by the action of the electromagnet. Ferrand has used this apparatus with some success for keeping the current constant in a dynamo-shunt. R. A.

1394. *Metallic Resistances.* **E. K. Scott.** (Elect. Rev. 43. pp. 71–72, 107–108, & 187–188, 1898.)—Six tables are given in which are tabulated the resistance, size of mandril, length of wire in a given spiral, weight, price, etc., of German silver, platinoid, galvanised iron, manganin, Kruppin, Hadfield's "Resista," and Brunton's "Beacon" material. The sixth table gives particulars of resistance, weight, and price of expanded metal (iron). In practice it is stated as usual to wind the wire as a close coil spiral, and then pull it out to double the length, but the smaller sizes below No. 15 B.W.G. require drawing out rather more to give the necessary stiffness. The "Beacon" alloy, made by Messrs. Brunton & Son of the Musselburgh Iron Works, Scotland, is given as having a resistance about 48 times that of copper and a temperature-coefficient of ·007007.

Extra large resistance-frames, for use in testing etc., may be cheaply made of ordinary galvanised iron-wire netting folded up and down on a large wooden frame. Or a strip of netting, say 12 inches wide and 1-inch mesh, may be wound round and round from the centre outwards, adjacent layers being spaced about 3 inches apart by means of ¾-inch diameter iron rods at the four corners of each convolution. The resistance of iron-wire netting, No. 20 B.W.G. 1-inch mesh and 12 inches wide, is given as ·005 ohm per yard of length, and the safe current with good ventilation may be as high as 90 to 100 amperes. Three designs for resistance-frames are illustrated, and also a diagram showing the distance apart of supports for wire spirals of various diameters It is stated to be mistaken policy to skimp the ironwork of resistance-frames, as the extra metal gives mechanical stiffness and materially assists the cooling. In America, grids made of cast iron have been used as resistances with success. The Siemens iron tube resistances, the "packed card" and tramcar rheostats of the General Electric Co. (U.S.A.), and the Carpenter and Stewart Electrical Syndicates' enamel resistances are described. With regard to these enamel rheostats, it is stated that, without reckoning in the area of the radiating ribs, the Carpenter type will dissipate continuously 5 watts per square inch of overall plate area; thus the size 10 inches square will dissipate 500 watts. AUTHOR

1395. *Gas Power.* **J. E. Dowson.** (Mech. Eng. 1. pp. 703–704, 1898.)—Practically the gas-engine trade began with the four-stroke cycle engine patented by Otto in May, 1876. From 1877 up to the end of 1897, the British and German makers sold 61,370 Otto engines, giving a total of 508,025 brake horse-power. The early engines had a compression of about 35 lbs., whereas the larger ones now compress to 100 lbs. per square inch before ignition; and the consumption of gas has been reduced from 32 cubic feet per brake

H.P. hour to about half that quantity. Engines are now built to indicate 220 H.P. each, and in one installation at Blackpool the gas-engines work regularly to 940 indicated H.P.

When town gas costs 3*s.* per 1000 cubic feet, the working cost of a gas-engine indicating 20 H.P. exceeds that of a steam-engine of the same power. Hence in 1878 the writer introduced a plant for producing cheap fuel-gas, which was tried in a Crossley engine in 1879. Results are given of trials made of the gas-power electric-light station at Leyton in 1896 and 1897. Four "Premier" gas-engines, of Wells Brothers, each giving 55 brake H.P., are driven by Dowson gas. Total fuel consumed, anthracite and coke, 0·9 lb. per indicated and 1 lb. per brake H.P. hour, and 2 lbs. per Board of Trade unit sold. Total cost of fuel, labour, etc., per unit generated is 1½*d.*

At Leicester 4 Crossley engines, each of 50 brake H.P., and 2 of 25 brake H.P. work with Dowson gas, and the total fuel consumed was reduced from 4·6 lbs. in 1895 to 3·03 lbs. per Board of Trade unit generated in 1897. At Halifax, 2 engines of 60 brake H.P. each drive dynamos, and use 1·01 lbs. of anthracite per indicated H.P. hour, and 1·92 lbs. per electric unit generated. Other instances go to show that the consumption of fuel in gas-engines with Dowson gas is much less than in the best type of steam-engine. Anthracite peas can be used, costing 6*s.* to 7*s.* a ton at the pit, and nuts and cobbles cost 5*s.* to 6*s.* a ton more, yet with care the peas can give rather better gas. Good clean coke also makes Dowson gas.

Ludwig Mond has a large plant producing fuel-gas from bituminous coal or slack, chiefly for the recovery of ammonium sulphate. Some of the gas is used for heating furnaces, and the rest for driving gas-engines. Each producer makes gas enough for 2000 indicated H.P. per hour, and must work continuously day and night. The plant is too large and costly for power purposes on a moderate scale.

The writer compares the repairs and maintenance of a gas-plant with that of a steam-boiler of the same power. In a Dowson gas-plant the firebars, hopper valve, and some of the brick lining of the generator, also coke in the scrubbers, have to be renewed occasionally, not oftener than once a year, besides painting of iron-work. The cost of repairs for plant varies with the size; between 100 and 500 indicated H.P. plant is about £4 to £14 per annum.
W. R.

1396. *Bending Heavy Rails.* (West. Electn. 23. pp. 29–30, 1898.)—This is a description of a bending machine designed by C. E. Moore, to bend 7-inch 90-lb. rails. The machine takes 12 H.P. to operate it, and curves a 90-lb. rail at the rate of 40 feet per minute. Formerly it required 9 men 4 hours to bend one 90-lb. rail. The cost of bending has been reduced from 13 cents. to 1 cent. per foot. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1397. *Sparkless Reversal in Dynamos.* **H. N. Allen.** (Instit. Elect. Engin. Journ. 27. pp. 209–238, 1898.)—The author gives a detailed account of measurements of the inductance of armature coils in different positions and under different conditions. The inductance was measured by (*a*) the alternating-current method; (*b*) the secohmmeter method; (*c*) using a search-coil connected with a ballistic galvanometer, and breaking a continuous current flowing through the coil under test. The measurements show, as might have been expected, that the apparent inductance diminishes with increase of frequency. An approximate method of calculating the inductance of a drum-armature coil is explained. The variation of flux through the pole-pieces in a running machine may be investigated by winding a coil on the pole-piece. The author finds that this variation of flux may sometimes be considerable, but that by properly adjusting the brushes it may be reduced to a very small amount. From certain theoretical considerations, as well as experimental results, he arrives at the conclusion that the magnitude of the reversing field is much less than it is generally supposed to be. A. H.

1398. *Commutation in Dynamos.* **P. Girault.** (Ind. Élect. 7. pp. 153–158, 202–206, 231–233, 250–253, 1898.)—This is an elaborate calculation on the effect of irregularities of either field-magnets or armature on sparking in dynamos. It is shown that small interpolar spaces are disadvantageous on account of the variations of the flux due to that armature-coil which is under commutation. The author thinks that carbon brushes are always more conducive to sparkless commutation than gauge-brushes. He is also of opinion that it is possible to make machines in which there will be reversal of current at the forward polar horns, and which will run sparklessly on account of the dragging of the armature flux by the armature itself for the coils under commutation, by employing a large neutral zone, sufficiently subdividing the armature, and using brushes whose resistances vary progressively. W. G. R.

1399. *Westinghouse Crane Motors.* (Elect. Engin. N. Y. 25. pp. 705–707, 1898.)—The Westinghouse Co. make dust-proof motors, both alternating and direct-current, for cranes. The direct-current motor is a four-pole machine, the yoke of the magnets forming a cylindrical case which is completely closed by end-plates through which the shaft projects. The brushes are attached to one of the end plates. The larger polyphase motors are started on a reduced voltage by a device called an autoconverter, by means of which it is possible to adjust a motor after installation, to have any desired starting torque within very wide limits. The crane-motors are provided with a regulator by which the pressure is varied; this gives a starting torque which is about four times the torque which the motor can develop continuously at high speed. A 40-ton crane, at the Westinghouse Machine Co.'s works, has two 20 H.P. alternating motors for the main hoist, one 10 H.P. for auxiliary hoist, two 5 H.P. for trolley travel, and one 20 H.P. for bridge-travel. R. B. R.

1400. *Polyphase Asynchronous Motors.* **W. G. Rhodes.** (Elect. Rev. 43. pp. 331–332, 1898.)—This is a descriptive account of the Boucherot system of polyphase motors in which the starting torque is increased by having two distinct stator windings, one of which can be rotated through an angular distance corresponding to half a period of the supply currents. The rotor is of the squirrel-cage type, and also has two circuits corresponding respectively to the two stator windings. AUTHOR.

1401. *Rotary Transformers.* **C. T. Child.** (Elect. Engin. N. Y. 25. pp. 608–609, 1898; see Abstract No. 986.)—The permissible output of a rotary transformer with a single winding depends not only upon its size, but on the nature of the supply current. It may be shown that the ratio of the copper losses in a rotary transformer to the corresponding losses if the machine were driven at the same output as a direct-current dynamo, is

$$\frac{8}{n^2 \sin^2 \frac{\pi}{n}} + 1 - \frac{16}{\pi^2} + \frac{4}{n} \tan^2 \beta,$$

where n is the number of rings on the alternating-current side of the transformer, and $\cos\beta$ the power-factor. From this it follows that for a rotary transformer of given size, the output would, in terms of its output as a direct-current dynamo, be as follows (assuming $\cos\beta = 1$):—

Single-phase.	Two-phase.	Three-phase.
0·85	1·64	1·34

It is thus evident that for a given output the 2-phase rotary may be made smaller than the 3-phase, and much smaller than the single-phase machine. As compared with the motor-dynamo combination, the rotary transformer possesses the great advantages of high efficiency, cheapness, and simplicity; it is self-starting on the alternating side, running up to synchronism without difficulty. Its disadvantages are the interdependence of the alternating and direct-current voltages and the very limited range of adjustment of the latter. But for railway or electrolytic work these disadvantages are not serious. A brief general description of Hutin and Leblanc's "panchahuteur" is next given; the extreme mechanical complexity of this form of rotary transformer is a serious disadvantage. But its efficiency is very high, and the output for size and weight remarkably large.—Some account of phase-transformers is next given, the arrangement due to Ferraris and Arno for deriving polyphase from single-phase currents receiving special attention. A. H.

1402. *Transformer Regulation.* **A. R. Everest.** (Elect. Engin. N. Y. 25. pp. 736–738, 1898.)—The author states that the direct experimental determination of the drop occurring in transformers is an extremely difficult matter, and that it is preferable to calculate this quantity from the known values of the copper and iron losses and the drop due to leakage, all of which quantities may be determined by experiment without much difficulty. He then proceeds to explain, by means of clock-diagrams, how the calculation may be carried out, illustrating the method by a numerical example. A. H.

1403. *Transformer Construction.* (Elect. Engin. N. Y. 25. pp. 746–747, 1898.)—The paper contains an illustrated description of the two standard types of large transformers made by the General Electric Co., viz., the "air-blast" and "natural draught" types. The former type is designed for continuous operation, large output, and high potential. The primary and secondary coils are assembled in small intermixed groups, each separately and heavily insulated, with air-spaces between them. The coils are placed in a vertical position, the core-plates being horizontal. The latter are also divided into a number of sections, with horizontal air-spaces between them. Along the air-ducts so formed a cooling current of air is forced from below through two sets of paths at right angles to each other, the air passing vertically through the windings and horizontally through the core. The motor driving the blower absorbs an amount of power which seldom exceeds $\frac{1}{4}$ % of the transformer output, and frequently is not more than $\frac{1}{10}$ %. Such transformers are used on 15,000 volt circuits or under, but may also be constructed for higher potentials. The rise of temperature above the surroundings is guaranteed not to exceed 40° C. The "natural draught" type is designed so as to offer a very large cooling surface. It is, for transformers of large output, much more expensive than the air-blast type, but for moderate output the cost per kilowatt is about the same for both types. "Natural draught" transformers are built in sizes ranging from 5 to 200 kilowatts, the standard pressures being 10,000 volts for the primary, and 3120 or under for the secondary. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1404. *New Plant at Niagara Falls.* **O. E. Dunlap.** (Elect. Engin. N. Y. 26. pp. 73–75, 1898.)—The Niagara Falls Hydraulic Power and Manufacturing Co. have just placed in operation the first turbine and generator installed in the extension of their power-house. The addition to the building is 60 ft. long by 100 ft. wide, bringing the total dimensions of the power-house up to 120 ft. by 100 ft. A steel penstock about 11 ft. in diameter has been constructed to supply water for the new turbines; it extends horizontally out from the cliff for about 60 ft. and then vertically for about 200 ft., finally passing under the floor of the power house. The first of the five new turbines to be installed is of the Jonval-Geyelin improved type, consisting of two bronze wheels on a horizontal shaft contained in a heavy cast-iron casing: the total weight of the turbine is 21 tons, and it develops 2500 H.P. This wheel is to operate two alternate-current generators, one of which already supplies current to the National Electrolytic Co.

Aluminium has been used for the conductors from this generator to the works; from the power-house to the top of the bank these conductors are bracketted to the penstock, and consist of bars 25 ft. long and 6 in. by ½ in. in cross-section, four being placed in parallel rivetted together; at the top of the bank each group of bars is connected to 12 aluminium cables rubber-insulated. The core of each cable is about 1¼ in. in diameter, composed of No. 10 wire. The total amount of aluminium in the conductors is about 22,000 lbs., the same work in copper would require about 48,000 lbs. The conductivity of the aluminium used as compared with copper of the same section is about 63 °/₀, but for the same weight it is more than double. Aluminium cables, although requiring more insulation, present many advantages, as the great strength and lightness of the material enable long spans to be used, reducing the number of poles and insulators required, while large cables can be handled and erected with ease and rapidity.

The paper contains a detailed description of the new turbines, alternators, switchboards, etc., and two views of the new penstock. M. G. W.

1405. *Power-Station at Toledo, Ohio.* **W. S. Smith.** (Elect. World, 31. pp 491–493, 1898.)—The author gives an account of the power-station recently erected by the Toledo Traction Company to meet the increased demands upon the power, traction, and lighting system controlled by this company. The chief point of interest is the arrangement of the generators. There is one Lake Erie engine of 1200 H.P. driving by belt one 6000-light Westinghouse alternator and one 5000-light G.E. alternator. Two 800 H.P. Porter-Allen tandem engines each carry on the shaft two 200-kw. G.E. lighting generators for the three-wire system. Four 1200 H.P. Wheelock cross-compound engines each drive by means of ropes one section of a shaft 198 feet long. These four sections may be all connected by means of friction clutches. At each end of the shaft are connected two 100-kw. G.E. generators for the three-wire system, and between these are a number of rope-driven machines; the latter include seventeen arc-lighters, four alternators, one booster, and three generators for the power service. Besides driving this shaft, each Wheelock engine carries upon its shaft a 500-kw. G.E. generator, three of these being used for traction and the fourth as a reserve for traction and power service. Owing to the combined traction and lighting supply, a comparatively constant load results, and the arrangement of plant described enables the machinery to be run at a higher load than would be otherwise possible. The Lake Erie engine supplies the alternating incandescent load, and the Porter Allen engines the direct-current load during heavy demand. As the lighting load diminishes, it is taken by the auxiliary dynamos on the shaft, so that for the greater part of the day the whole load is taken by the traction plant. W. R. C.

1406. *Accumulator Tramway Traction.* **E. Hauswald.** (Écl. Électr. 15. pp. 536–543, 1898; abstract of a paper read before the Elektrotechnischer Verein, 25 Jan. 1898.)—The author, after making some general statements as to the desirable characteristics of a traction cell, refers to the Pollak cell, and states two experimental laws:—(1) A plate will only bear a high rate of discharge if the discharge amounts to a fraction of its normal capacity. (2) The higher the efficiency at which a plate is worked the longer is its life. Curves are given showing the variation of efficiency with rate of discharge and with the amount of discharge. The author calculates the power required to propel a car. The mean results obtained on the accumulator line at Frankfort show that the energy required per car-kilometre for an 8-ton car travelling at 15 kilometres per hour is as follows:—

	Watt-hours.
Without stops	180
With 3 stops, battery coupled in series at starting	320
With 3 stops, battery coupled in parallel at starting	260

It therefore appears that accumulator-cars can be run at 30 to 40 watt-hours per ton-kilometre, instead of 60, which is the generally accepted figure. Having regard to the above laws, the battery employed should be small, discharged to only a small extent and frequently recharged. This system is employed at Frankfort. The cars carry 42 passengers, but only weigh 8 tons, including a battery of 84 T_6 Pollak cells. A single motor of 15 H.P. is provided. The batteries are charged at the rate of two minutes per kilometre run, at constant pressure so that gassing does not take place; once a week they are charged up to 2·5 volts per cell. The battery efficiency amounts to 85 °/₀. Such a system is only suitable for short lines. When the distance exceeds the efficient limit, mixed traction may advantageously be employed, the trolley line being sufficiently long to give the requisite charge.

The author also considers accumulator-traction for suburban railways.

Hopfelt remarked that the first above mentioned law applies to Faure, but not to Planté plates. W. R. C.

1407. *Cost of Electric Traction at Leeds.* (Railway World, 7. pp. 142–143, 1898.)—The cost of tramway traction at Leeds is discussed. The following figures were obtained for the week ending March 28 last, and may be considered as a fair average:—

Total receipts from 21 electric cars	£656 16*s.* 4*d.*
Total car-mileage	14,777
Receipts per car-mile	10·66*d.*
Expenses per car-mile (including depreciation, renewals, repairs, interest, and sinking-fund)	8·60*d.*
Surplus per car-mile	2·06*d.*

The working expenses per car-mile, with no allowance for depreciation or repairs, is made up as follows:—

Electric-car shed..................	·57*d.*
Generating station	·69*d.*
Management and office	·32*d.*
Electric engineers' salaries.............	·13*d.*
Wages of drivers and conductors	1·84*d.*
	3·55*d.*

The energy used per car-mile amounted to 0·960 unit, and the cost of generation was 0·72*d.* per unit. The interest charged appears to be at the rate of 2¾ per cent. on the Corporation Loan; the sinking-fund is at 2¼ per cent. Depreciation, renewals, and repairs are all included in a sum of 7½ per cent. on the capital.

W. R. C.

1408. *Equipment and Maintenance of Tram-cars.* **M. S. Hopkins.** (Elect. World, 32. pp. 284–285, 1898: abstract of a paper read before the American Street Railway Association, Boston, Sept. 1898.)—The author discusses car-bodies, trucks, and electrical equipment; and then passes on to the question of maintenance. The paper scarcely admits of a short abstract.

W. R. C.

1409. *Eddy Electric Carriage Motor.* (Elect. Engin. N.Y. 26. pp. 83–84, 1898.)—The results of a Prony-brake test of an Eddy carriage motor are given in curves showing speed, torque, and efficiency. A motor for driving a two-seated carriage weighing 1800 lbs. at 12 miles per hour on good macadam roads weighs 128 lbs., and will stand a maximum load much in excess of its average load. E. H. C.-H.

1410. *G.E. Narrow-Gauge Traction Motor.* (Street Rly. Journ. 14. pp. 459–460, 1898.)—A fairly detailed description is given of the new G.E. 58 narrow-gauge motor of 37 H.P., designed for a minimum guage of 1 metre. The weight complete, with gear and gear-case, is 2150 lbs. W. R. C.

1411. *High-Speed Traction Motor for Suburban Service.* (Street Rly. Rev. 8. pp. 465–466, 1898, and Elect. Engin. N.Y. 25. pp. 720–721, 1898.)—The new type of General Electric Company's high-speed motor, known as G.E. 51-B, is illustrated and described. The capacity of these motors is 80 H.P., based on a rating of 75° C. rise in temperature of the windings above that of the surrounding atmosphere after an hour's run at rated load. A double equipment of these motors will propel a 20-ton car at a maximum speed of 26 m. p. h. on a level, with the gear-ratio of 2·27. Mounted on 33″ wheels, the clearance below the bottom of the frame is 3 inches. E. H. C.-H.

1412. *Trolley Line Construction.* **D. Pepper,** jun. (Frank. Instit. Journ. 146. pp. 55–62, 1898.)—Description is given of the chief points in construction of modern line-work. The limitations of the overhead trolley are stated to be 150 amperes, and 10 miles per hour. E. H. C.-H.

1413. *Sectional Conductor Electric Tramways.* **G. T. Hanchett.** (Elect. World, 31. pp. 494–497, 554–555, 586–587, & 645–648, 1898.)—The author gives a critical account of a number of sectional conductor systems. But no names are given, and no reference to actual trials of any system. W. R. C.

1414. *Street Lighting.* **H. Hopkins.** (Elect. Engin. N. Y. 25. pp. 731–733, 1898.)—The author briefly compares electric-arc lighting with other systems as regards reliability, cost, etc., and gives illustrations showing arc lamps in position. A. H. A.

1415. *Arc-Lighting Plant driven by Polyphase Motors.* (Amer. Electn. 10. pp. 239–244, 1898.)—A description is given of the arc-lighting plant of Brooklyn, U.S.A., which is now driven by three-phase synchronous motors in place of the steam-engines formerly used. Each motor is supplied at 6000 volts from the Union Station, and drives two 120-light Brush machines through flexible couplings; the motors are self-starting, with rotating field-magnets and ball bearings. A full description of the construction of the arc-light machines is given, with illustrations. Each 240-light unit occupies a floor-space of about 20 ft. × 5 ft. A large storage battery is installed, with transformers and rotary converters, and is able in case of need to maintain the supply not only to the low-pressure mains, but also, by reversing the rotary converters, to the polyphase motors driving the arc-lighters.

A. H. A.

1416. *Dick's System of Train-Lighting.* (Zeitschr. Elektrotechn., Wien, 16. pp. 321–327, 1898.)—A detailed description, with a sketch of the electrical connections, of Dick's system of train-lighting. Each carriage is provided with a battery of 57 small secondary cells, capable of giving a current of 3 amperes for over 8 hours. The batteries are joined in parallel across main conductors running the entire length of the train, connection between neighbouring carriages being established by means of flexible conductors. A single 12-H.P. dynamo, mounted after the manner of a tramway motor, so as to be driven off the carriage-axle by toothed gearing, is used for either charging the cells or supplying the lamps direct, in which case the cells act as regulators. An elaborate array of electromagnets controls the various automatic switching arrangements, the required constancy of E.M.F. with variable train-speed being obtained by throwing more or less resistance into the field-circuit. The only hand control is that of a simple two-way switch attached to each carriage, in one position of which the lamps are on and in the other off. A. H.

1417. *Richter's Electric Miner's Lamp.* (Électricien, 15. pp. 275-277, 1898.)—This is an accumulator lamp, and the improvements relate more particularly to the box and fittings. The box is provided on opposite sides with terminal sockets of different sizes for charging, these sockets being connected by double plugs; the ends of these plugs are of different diameters, to correspond with the sockets, so that the batteries can be readily coupled up in series for charging without risk of any of the batteries being connected up in the reverse direction. Some drawings are given in the paper, but the description is not very full. The lamp weighs 3 kilos, burns 10 hours, and gives 3 c.p. C. K. F.

1418. *Repairable Incandescent Lamps.* **C. Howard.** (Électricien, 15. pp. 280–281, 1898.)—In this lamp the platinum leading-in wires are provided with internal extensions of nickel wire, the ends of which fit into small sleeves or sockets; and into the other ends of these sleeves fit nickel wires bearing the filament and connected by a bridge-piece of glass. The neck of the lamp is extended to receive the sleeves and nickel wires, and is provided with ribs and a flange to prevent turning and lateral displacement of the lamp in its cap. To replace a filament, the neck of the lamp is cut near the middle of its length, the nickel wires bearing the filament removed from the sleeves or sockets, and a new filament with its nickel wires placed in position; the filament and its supports can then be inserted into the bulb, the lamp sealed up and exhausted. It is estimated that all the operations between the opening of the lamp and its replacement in working order cost less than 0·09 franc (0·865*d.*). C. K. F.

TELEGRAPHY AND TELEPHONY.

1419. *Cable Relay.* **K. Gulstad.** (Elect. Rev. 42. pp. 792–794, 1898.)—The author concludes his description of the vibrating relay referred to in Abstract No. 1007, and elaborates the method of working a cable on such a system. By means of curves of potential he seeks to show that, in general, the interference of the "sent" signals brings the vibrations of the relay-tongue into unison, and practically into synchronism with the reversals of the transmitter, in such a way that, while the transmitter sends a positive impulse into the cable, the relay sends a negative impulse into the cable at the receiving end, as well as into the third branch of the "T." The effect of varying the receiving- and adjusting-condensers is illustrated by recorder "slip." It is claimed that by the use of a vibrating relay the distortion of signals on undisturbed lines may be nearly eliminated, by adjustments similar to those applied in duplex working; and it is suggested that a vibrating relay might be used with actual duplex. Using an artificial cable a speed of 90 words per minute, with a "KR" of 700,000, has been attained, presumably with auto-sending. On the Newcastle-Gothenburg cable (KR=580,000), by this system, 110 words per minute have been sent from Newcastle and translated at Gothenburg to Nystad in Finland. On this cable a modification of the vibrating relay, due to Falck, gives 65 words per minute. In conclusion the author expresses an opinion in favour of increasing the currents used for working cables. R. A.

1420. *Wireless Telegraphy and Electromagnetic Waves.* **Della Riccia.** (Bull. Ass. Ing. El., Liège, 9. pp. 95–155, 1898.)—Describes Marconi's apparatus, and explains the nature and properties of electromagnetic waves. J. L. H.

1421. *Photo-Telegraphy.* (Elekt. Runds. 15. pp. 232–233, 1898.)—In 1887 Hertz showed that if the spark-gap of an induction-coil is widened just beyond the ordinary limits of sparking, a spark can be forced across it if a beam of ultra-violet light is directed into the gap. Zickler, of Brünn, now proposes to utilise this for the purpose of space-telegraphy. At the sending station an arc-lamp is provided with a shutter apparatus and a suitable lens or mirror for directing flashes towards the receiving station. The light of the arc is very rich in ultra-violet rays; it is therefore able to cause a spark to pass at the gap of an induction-coil at the distant end, and thus to affect a coherer-circuit. Signals have been transmitted in this manner through 200 metres, using an arc-lamp taking 25 amperes at 54 volts, and concentrating the light by a quartz lens 4 cm. in diameter. R. A.

1422. *Automatic Telephone Exchanges.* (Electrician, 41. pp. 52–53, 1898.)—Describes the apparatus of "The Direct Telephone Exchange Syndicate, Limited." Two lines are necessary for each subscriber, and in addition either an earth-return or, preferably, a return wire common to all subscribers. The subscriber's instrument is provided with a disc in which are holes numbered 0 to 9. The calling subscriber selects the successive figures of the required subscriber's number and operates the disc for each figure. He then turns the handle of his magneto-bell. If the connection is made, his bell rings. If the required number is already engaged, his bell does not ring. The operation of the disc first makes a combination circuit from one or other of the lines with the common return, and secondly sends a number of current impulses over the selected circuit.

In the central office mechanism, an insulated segment of impregnated plaster-of-Paris has placed upon it 100 contacts in 10 columns of 10 rows, each contact representing one subscriber to the exchange. A "wiper" connected to a movable shaft travels over the segment and is brought into position over the particular contact required by means of the combination lines and the current-impulses transmitted over them from the calling subscriber's instrument. Mechanism is provided whereby a connection to an already engaged line is prevented. At the central office each subscriber's line is provided with the selective apparatus upon which each line is "multipled" twice—first, for connection purposes and secondly for preventing connection in case of engagement. In exchanges exceeding 400 lines a supplementary automatic switch is necessary for each subscriber.

J. E. K.

1423. *Telephones on Toll System.* **H. P. Clausen.** (West. Electn. 23. p. 162, 1898.)—Summary of methods of calling attention.

M. O'G.